Research on making BRICKS from DECOMPOSED MUNICIPAL SOLID WASTE

REPORT

for MMR-Environment Improvement Society

This Research Work is Dedicated to the Community...

This Research Work is carried out between October 2003 to May 2005 at Deonar Dumping Ground of Municipal Corporation of Greater Mumbai, Mumbai 400 043, Maharashtra, India. For further reference please contact :

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1. EXECUTIVE SUMMARY

1.1 Rapid Urbanisation :-

Rapid urbanization during last few decade has led to several issues, including management and disposal of Municipal Solid Waste (MSW). The studies indicate that the quantum of waste generated is higher in bigger cities due to high level of economic activities and consumption pattern. The management of Municipal Solid Waste (MSW) is the obligatory duty of the urban local bodies, however, in the cities and towns in India leaves much to the desire, and is the root cause of public health and environment problems. Taking cognizance of the consequences of mismanagement of Municipal Solid Waste particularly in the wake of Surat Plague in 1994, the Supreme Court of India set up an Expert Committee to recommend the measures to improve the waste management particularly in Class-I cities in the country. Simultaneously, the Ministry of Environment & Forest, Government of India, notified the Municipal Solid Waste (Management & Handling) Rules 2000. These rules alongwith the recommendations of the Expert Committee of the Supreme Court mandate scientific method of MSW collection, transportation, treatment and its disposal at sanitary landfill. The underlying principle of these rule is of recycling of waste and the disposal of residual waste into sanitary land fills which will protect the environment from being polluted by the erroneous city waste.

1.2 MSW in Mumbai :-

The City of Mumbai which is one of the largest urban agglomerations in the World, generates about 7000 MT of waste everyday. This is disposed off at three land fill sites namely Gorai; Mulund and Deonar located outskirts of Mumbai. These landfills are fast heading towards a saturation level. Landfill sites may lead to severe environmental problems which will affect the people living in the City. Already there has been a demand to close the land fill at Gorai similarly either to close or drastically improve the sites at Deonar and Mulund. As per estimates prepared by the Solid Waste Management Cell of the Government of Maharashtra, Mumbai, more than 700 hectares of land will be required during the next 25 years, if all waste is disposed in the way it is done at present. In a city with limited geographical area and the constraints of Coastal Regulation Zone along with heavy pressure of colonization, the availability of land of this size may be no better than a dream. The only option therefore, is to reduce the waste

itself at the point of generation through segregation and recycling, and also to enhance the capacity of the existing landfill through waste treatment and perhaps by mining and recycling the old stabilized material.

1.3 Research Project :-

Municipal Corporation of Greater Mumbai in collaboration with Veermata Jijabai Technological Institute (VJTI), Mumbai, carried out a three pilot studies focusing on utlisation of old stabilized material for making construction bricks. The objective of this study was to establish the technology of converting stabilized waste into building bricks. The study carried out prima facie indicates that the MSW can work as soil substitute in making building blocks and bricks. The study concluded that, if the stabilized waste could be used as soil substitute, it would reduce erosion of the agricultural land to a great extent which takes place as a result of removal of top soil for normal brick making.

Considering the encouraging results of the study, the MCGM and VJTI approached the Solid Waste Management Cell of the Govt. of Maharashtra and All India Institute of Local Self Govt. (AIILSG) for supporting further study which could firmly establish the technical feasibility of the above technology and help in establishing a reliable option of waste utilization. The SWM Cell, Municipal Corporation of Greater Mumbai and the VJTI moved a research study proposal to Mumbai Metropolitan Region Environment Improvement Society (MMR-EIS) for financial support. After several rounds of presentations and discussions, the MMR-EIS approved the research project.

1.4 Objective of Study :-

The over all objective of the research study is to establish a process and technical feasibility of brick making by using Municipal Solid Waste, stabilized over years at the landfill sites. It is also intended under the project to identify the environmental implications, if any, of brick making activity, if started within the city area. A reference to marketability of such burnt bricks is also a part of the objective.

1.5 Methodology :-

The methodology for this research project is to draw MSW samples at various strata from landfill site at Deonar, testing and analysing the samples at Soil Mechanics Laboratory, Structural Engineering Department

and Environmental Laboratory of Civil Engineering Department in the VJTI. The methodology also included bacteriological analysis at G.S. Medical College, K.E.M. Hospital with a view to identify possible health and environmental hazards while making bricks from this material. The literatures overview and consultation with experts involved in civil engineering activities and building material technology was also accepted as part of the methodology.

Accordingly, 128 numbers of samples were drawn by trial pit and boring method employing an agency through the bidding process. The samples were analysed for physical and chemical composition; similarly for microbiological analysis. Number of brick kilns were set up at Deonar to burn the bricks made from various mixes drawn by permutations and combinations of various quantities of MSW, agricultural soil and fly ash. These bricks were tested for compressive strength and water absorption. The results obtained from the testing provided deep insight of not only of the possibility of making good bricks of acceptable standards from MSW but also of the technological improvements in making bricks. The conclusions drawn will help the brick making industries at large. A workshop was also conducted in November, 2004, to discuss the preliminary findings of samples drawn and the test reports of the bricks, with experts from building activities, environmentalists and scientists from environmental and civil engineers streams.

1.6 Enlarged scope of study :-

During the course of the study, the scope of research work was extended to the issue of handling debris waste which is deposited in huge quantity and needs immediate solution. Analysis of MSW in Mumbai indicates nearly 17.5% to 37.5% of debris component in the MSW. It was discussed that if the demolition debris, in particular, could be recycled into making building material such as building blocks, the problem of disposal of MSW could be significantly mitigated. Fly ash from Thermal Power Plants, currently poses another threat to environment, could also be used for brick making along with solid waste. The research study explored the possibility, to use fly ash as one of the ingredients for MSW based bricks, in order to reach a desired level of chemical and physical composition of the raw material required. The project team also visited the fly ash based brick making unit in Koradi near Nagpur to study how fly ash is being used in this

activity and the extent to which fly ash could be used to strengthen the MSW and agricultural soil combinations.

1.7 Indian Standards for Brick Making and Working Hypothesis :-

As a part of this research project, Indian Standards of Brick Making were considered as theoretical base to test the feasibility of making bricks from different materials.

Traditionally building bricks are made by cutting top layer of agricultural soil which generally has the following chemical composition:-

Silica (SiO_2)	37% to 48%
Alumina (Al_2O_3)	20% to 32%
Calcium Oxide (CaO)	5% to 7%
Ferric Oxide (Fe_20_3)	11% to 13%

The working hypothesis were that the combination of different material should be able to make the above percentage of these chemicals in order to give bricks of desired and approved standards.

Process of brick making comprises :-

Mixing of raw material in such quantity to satisfy the above chemical standards, make brick block, drying and burning in age old traditional bhatti / kiln, so that brick gains strength more than 30 and water absorption limit of maximum of 25%.

The results obtained from this research study indicate that MSW soil can be used for brick making in combination with fly ash and/or agricultural soil.

1.8 Building blocks from debris :-

As mentioned earlier, the research study was extended to include the treatment of building demolition debris, to explore the possibility of making building blocks. The project team approached several Industrial Units and experimented use of debris for making building blocks. The results of the experiment indicates that the combination of debris along with cement, sand, aggregates, can give building blocks of required quality. In addition, it is established that even paver blocks prepared by using debris, cement, etc.; can also provide foot path pavers.

1.9 Impact on Environment :-

The project team carried out a environmental study of the brick making activity at Deonar. The survey of ambient air quality due to brick

burning was carried out in collaboration with Air Pollution Monitoring Unit of Thane Municipal Corporation. The results indicate that there is no significant increase in the pollutants as a result of brick burning.

1.10 Demonstration of the Technology :-

During the course of study the project team organized consultation with the Builders and Developers in collaboration with Indian Merchants Chamber. The consultation highly appreciated innovative work being carried out under this project and recommended that the bricks made of MSW should actually be used to demonstrate the technology. Accordingly, the bricks used during the pilot project, were first used to construct the flower bed in the Cathedral & John Cannon School, Middle School, 4, Maharishi Dadhichi Marg, Mumbai-400 001. These bricks were also used in making flower beds along Ridge Road at Malabar Hill in collaboration with a NGO called AGNI. A structure constructed at Deonar Dumping Ground itself to study the reliability of these bricks in building making. The structure withstood heavy rains of July 2005 and still intact without any damage or effect on strength.

1.11 Broad Conclusions :-

- MSW excavated at any location is found to content about 47% to 52% soil material of less than 10mm in size thereby can be used for making the bricks.
- The remaining 48% to 53% of material is greater than 10mm size and is also very useful, as it contains various kinds of recyclable material and if it is segregated properly it would be very useful product and fetch a good value.
- MSW has deficiency in silica, alumina and ferric oxide and calcium oxide as compared to the brick clay / agricultural soil. Similarly, the quantum of finer material is less in it. These deficiencies could be removed by addition of fly ash from Thermal Power Station or agricultural soil.
- Presence of heavy metals like chromium, lead, copper, zinc in MSW is in traces.
- On the basis of microbiological analysis it is seen that precautions in terms of cloth mask, gloves, gum boot etc. to the labourers will be essential while making the bricks from the MSW. Regular health check up of the people working in this

field is also advisable.

- The brick cannot be made exclusively from MSW soil, however, by addition of agricultural soil or fly ash to the minimum extent of 10%, the bricks can be made which satisfies the required standard.
- Very experienced personnel needs to be employed for all these activities.
- The handling of bricks before and after burning needs to be carried out very carefully to avoid its damages.
- During these experiments the cost of making brick varies from Rs. 1.00 to Rs. 4.00 per brick.
- Considering requirement of brick in the city the process of manufacturing needs to be mechanized.
- On mechanization or even with conventional process if bricks are manufactured in large quantity the cost may be around Rs. 1.00 per brick.
- It is to mention that, normally, the cost of regular brick in the market is varies from Rs. 1.80 to Rs. 2.50 per brick.
- Presently bricks are coming in city by transport from almost 70 to 80 kms distance and by virtue of making bricks at dumping ground the transport will reduce. Therefore, savings in fuel, reduction in fuel emission which leads to reduction in cost of bricks and protection of environment.
- The room constructed by use of these bricks at Deonar dumping ground about two year back has shown very good result.
- Ambient Air Samples collected during the burning of bricks shows that all values of SO_2 and NOx and SPM are within the permissible limit.
- Some of the benefits derived from making of bricks by use of MSW and fly ash are as follows :-

- Huge quantum of MSW will be used.
- Expansion of dumping ground will stop thereby no requirement of new land for dumping ground.
- It will facilitate extensive segregation and use of recyclable material.

- Provides solution for conversion of complete MSW into useful products.
- The recyclable material will provide very good value.
- The fly ash will be used in huge quantity.
- The cost of brick will be less.
- The bricks will be available in huge quantity and as per requirement.
- The manufacturing process will take place at single location thereby complete quality control can be maintained.
- The size and shape of brick can be made as per requirement of client.
- Mechanisation will facilitate manufacturing even during monsoon which is not the case with normal bricks.
- Barranization of agriculture field will stop to great extent.
- Due to stoppage of expansion of dumping ground the damage to the environment will also stop.
- There will be saving in fuel and reduction in fuel emission.
- Exploitation of labourer will be stopped.
- At the end, this research work provides very innovative and extremely environment friendly solution to almost all problems created by two major solid waste i.e. MSW and fly ash.

1.12 Future Activity :-

To develop the guidelines for the Commercial Viability, Manufacturing and Marketing, so that Entrepreneurs can come forward at various locations for utilizing Decomposed Municipal Solid Wastes and other Solid Wastes for construction industry.

Commercial Viability is needed to realize the concept from this study and to make the project into reality. Studied guidelines for the Manufacturing and Marketing are necessary to raise the confidence levels of the prospective entrepreneurs.

The activities involved are as follows :-

- Identifying Preferred Mix Designs for various items, uses and commercial viability.
- Requirements of Manufacturing
- Preparing samples and offering commercial use and observing their reactions.

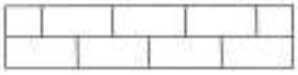
- Guidelines for promotion of construction materials made from Municipal and other solid wastes including incentives from various authorities.
- Issue of carbon credit.

1.13 Implementation :-

Who so ever interested in resolving the issue of dumping of MSW and unable to carry out brick making activity due to non availability of agricultural soil and number of other reasons, may start utilising this research work. Depending on site conditions and availability of raw material number of combination of mixes can be used, however, following combinations are suggested for getting better burnt bricks, provided uniform heating and cooling is achieved in kiln, for optimum results.

Quantity in %

MSW	Fly Ash F2	Agricultural Soil
75	25	-
50	50	-
80	10	10
70	-	30



2. BACKGROUND

2.1 Introduction :-

Urbanisation is a common phenomena seen worldwide, mainly due to concentration of economic activity, shifting of population, etc. Many places, it is also seen that areas which were earlier rural, is getting converted into urban localities. Urbanisation has very important feature of increased standard of living, demand of more and quality services. The population becomes more and more dependent on each other for various services, particularly civic services. It has become stupendous task for the Urban Manager to provide civic services and satisfy the demands of population. The most essential services like water supply, roads, drainage, electricity, MSW, etc., are being generally provided by the Govt. organisations and local bodies, however, it is seen that the citizens are not fully satisfied and the MSW is one of such issue. MSW involves collection, transportation and disposal of garbage. Procedures are laid down for all these activities, however, due to various factors it could not be followed in totality. Generally, it is seen that, Solid Waste is disposed off at low-lying areas, which are normally called as "land fill sites". Land fill sites are generally located at the outskirts of the cities, however, by its expansion, such sites become a part of city and nuisance to the population living around.

Most of the disposal sites in India are just uncontrolled dumps where a mixture of domestic, commercial, industrial and hospital wastes are dumped together. This creates air pollution, ground water and soil contamination etc. Open dumping of wastes generally becomes ground for various dreadful diseases, particularly in the vicinity of the disposal sites.

2.2 Municipal Wastes Management and Handling :-

In order to streamline MSW management, Ministry of Environment and Forest (MOEF) has promulgated the "Municipal Wastes (Management and Handling) Rules, 2000" under Environment Protection Act (1986) which addresses various aspects of waste management viz. collection, transportation, storage, recycling, processing, disposal, etc. These Rules emphasizes integrated approach starting from house-to-house collection to processing of organic waste and scientific disposal of inert wastes. As per the rules, implementation time schedule was as follows:-

1. Improvement of existing landfill sites by 31.12.2001
2. Identification of landfill sites for future use and making site ready for operation by 31.12.2002.
3. Setting up of waste processing and disposal facilities by 31.12.2003.
4. Monitoring the performance of waste processing and disposal facilities once in six months.

From above it is clear that apart from scientific way of management of solid waste in the city; the Rules have stipulated specific dates for complying with the requirements.

2.3 Existing methods of disposal of solid waste :-

The number of innovative methods have been tried for reducing and reusing the Solid waste. Methods available for both consuming and reusing the Solid waste is found either time consuming or economically not viable. At the same time, these methods are unable to take care of huge Solid waste generated. Methods like Vermiculture, Composting, Pellatisation, Biomethanation, Generation of electricity etc., are being tried, however, it is found that these all methods are expensive and require large quantum of land, which normally scarce in the urban area.

For effective disposal of urban solid waste Bureau of Indian Standards, has framed guidelines under Indian Standard 9533 of 1980 which are reproduced below.

2.3.1 Sanitary land filling :-

- Urban solid wastes may be dumped on land. Such uncontrolled, haphazard dumping leads to unhygienic conditions and is objectionable from aesthetic point of view. Such dumps often attract rag-pickers who, during their activities, scatter the material, thus forming an eyesore to the residents of the surrounding areas. These disposal sites may also result in prolific breeding of rats and other vermin thereby endangering public health.
- However, a large majority of Indian cities continue to use this method and some reclaim low lying land by using slightly modified form of land filling. This process has been systematized and made more sanitary and efficient and is known as sanitary land filling.
- In this method the waste is deposited in 1.0 to 4.5 meters thick layers in either natural or man-made depressions and then compacted to the

smallest practical volume and covered at least once a day by adequate quantities of soil or other inorganic material. This covering precludes the possibility of fly breeding, rat burrowing, etc.

- Sanitary land filling may be carried out in three ways as follows :
  a) Trench method,
  b) Area method, and
  c) Ramp method.
- The trench method is preferred for flat terrain, the area method for irregular, undulating or marshy land, and the ramp method for flat or gently rolling areas. It is possible to adopt sanitary land filling for disposal of all types of wastes on all types of land. As most the cities already use the crude form of dumping, suitable sites already exist which, after minor modifications and investment, can be converted into sanitary landfills.
- Sanitary land fill sites should be properly selected so as to avoid possible pollution of surface or ground water. The amount of pollution in g/kg of refuse, based on studies carried out in India is given in Table below. For the sake of comparison and suitable modifications under Indian conditions data from Switzerland is also given.

Sr.No.	Constituents	Indian Refuse (1972)	Swiss Refuse (1968)
i)	Sulphate	0.12	0.54
ii)	Chloride	1.76	0.232
iii)	Nitrite	0.00032	0.00002
iv)	Nitrate	0.00347	0.034
v)	Ammonia	0.30	0.0001
vi)	Permanganate value	0.288	0.078
vii)	BOD	17.56	0.011

- The larger organic content in Indian refuse is reflected in larger pollution values. To avoid such pollution, sites should be properly selected and in cases where pollution is likely occur, suitable measures should be taken to stabilize the soil by compaction, addition of chemical reagents to the surrounding soil, or by interposing plastics membrane between landfill and the surrounding soil.
- Some studies have revealed that under Indian conditions, a volume of 9 to 10 M^3 is adequate to take care of 100 tones of refuse per day for 25

years. The area needed for the landfill can, hence, be calculated when depth of the fill is known.

➢ Land fill sites should be provided with suitable water for fire-fighting and for drinking purposes. Necessary mechanical equipment, such as bulldozers and scrapers should also be provided.

➢ Pollution of Ground water by refuses (g/kgs)

➢ Sanitary land fill can accept all types of wastes. However, it is desirable to provide separate land fill sites for hazardous wastes. Even if the principal disposal method is composting or incineration, sanitary landfills should always be provided for disposal of non-decomposable material and incinerator residue.

➢ The advantages and disadvantages of sanitary land filling when compared with other methods are as follows:

Advantages :-

a) The process can be made sanitary;
b) Highly skilled personnel is not needed;
c) It can be safely overloaded without causing any problems;
d) It converts low lying marshy waste land to useful areas having a resale value;
e) Natural resources are returned to soil and recycled;
f) Stabilized material may be excavated and reused, if necessary and then the land may again be used for filling; and
g) This has been found to be the cheapest method of disposal in India.

Disadvantages :-

a) A large land-space is required and this is mostly available away from the town. Due to larger distance, the transportation cost is substantial; and
b) Spontaneous ignition may occur due to methane formation in wet weather.

2.3.2 COMPOSTING :-

The degradable fraction of the waste, as a result of biochemical reactions, is degraded to a stable form called 'compost'. This compost, when applied to soil, is known to increase the moisture retaining and ion-exchange capacity of the soil. It also contains a small proportion of plant

nutrients (N,P,K) which cannot be easily leached away and are observed to be slowly released for utilization by plants.

The composting process may be carried out either aerobically or anaerobically. During the aerobic process, more energy is released and comparatively higher temperatures up to 70°C are recorded, thereby ensuring hygienic safety of the product. Also, due to the faster rate of reaction, the final product is obtained much earlier.

Advantages :-

- It increases water retaining and ion-exchange capacity of soil to which it is added;
- In addition to Municipal solid waste, a number of industrial solid wastes can be treated by this method;
- It can be sold, thereby reducing the cost of disposal; and
- Recycling of soil nutrients.

Disadvantages :-

- Mechanization involves relatively high capital and operation costs;
- Disposal of non-compostables has to be done separately; and
- The product does not have an assured market.

2.3.3 INCINERATION :-

- Incineration is a refuse reduction process wherein the organic part and moisture of refuse is converted to normal components of atmosphere by enclosed and controlled combustion. The primary products are carbon dioxide, water vapour and nitrogen and a solid residue of broken glass, ceramics, metals and mineral ash. Normally 200 to 300 percent excess air is supplied, to ensure complete combustion, which carries away the gaseous products while the solid residue, termed as clinker, is removed separately.
- There are various types of units, each suitable for a specific purpose. The modern trend is to use heat utilisation type units rather than the non-heat-utilisation type. In a still modified form, utilisation of refuse (after some treatment) as a fuel along with or as fuel alone in thermal power plants is being increasingly preferred. The heat can be utilised for raising steam or power generation, the latter being commonly preferred. To obtain proper and complete combustion, movable grates are increasingly preferred to fixed grates. Also it is desirable to maintain high furnace temperature and

avoid high grate temperature, so as to avoid clinkers blocking the grates. To ensure complete combustion of the charge, and to reduce air pollution problems, the rates of primary and secondary air supply have also been standardized.

- The tendency of enacting more and more stringent air pollution control regulation has resulted in provision of more complicated and hence costly air pollution control equipment which is making the operation of the incinerators more costly. However, it has to be borne in mind that the pollutants likely to be introduced by incinerators are negligible as compared to those introduced by industries and automobiles.
- For economic operation of incinerators the refuse should be such as would give a self-sustaining combustion reaction. Figure 1 shows the zone in which such a reaction can be obtained. It can also be seen from Fig. that majority of Indian refuse lines outside this zone and would need auxiliary fuel, thereby boosting the cost of incineration. Hence, in India, incineration would prove to be economical in cases where either a self-sustaining combustion reaction can be obtained or where the total cost of collection and disposal will be reduced due to its location within city limits. The incineration method is commonly used for the disposal of hazardous toxic wastes.
- The advantages and disadvantages of this process, as compared to other methods of disposal are as follows.

Advantages :-

- Residue is only 20 to 25 percent of the original mass. The clinker and fly ash can both be utilised after suitable treatment;
- It requires very little space;
- It can be located within city limits which reduces the cost of transportation; and
- This process is safest from the point of view of hygiene.

Disadvantages:-

- Its capital and operating cost is higher,
- It needs skilled personnel, and
- It may cause air pollution.

2.3.4 PYROLYSIS :-

➢ In this process, solid waste is burnt in the presence of insufficient oxygen when a number of intermediate products are formed and recovered. If the burning temperature is above 900°C, a fuel gas is mainly produced along with some other residue. In case of burning is carried out at 600°C, an oily liquid having properties similar to diesel fuel and char are obtained. The char can be used after suitable treatment.

➢ Full-scale units of high temperature pyrolysis type have been constructed and the mass balance obtained is given in Table below. Part of the gas (85 percent of total) can be used in the plant itself and the remainder 15 percent (having heat value 910 kJ/kg refuse input) can be sold. The char can be converted to activate charcoal and used in water and sewerage treatment, or sold. Some unburnt or partially burnt residue has to be land filled and the waste water has to be let off to sewers.

Mass Balance in high temperature Pyrolysis*			
INPUT		**OUTPUT**	
Amount	**Energy**	**Amount**	**Energy**
1 Kg Refuse	Net Calorific Value7330 kj/kg	0.285 kg dry slag	Calorific value 10 470 kj/kg Net - 3.000 kj
		0.285 kg water	-
		0.35 kg (0.5m^3)	Calorific value 12 140 kj/m^3 Net = 6 070 kj
		0.04 kg scrap	-
		0.04 kg losses	-

* For a plant in Kalundborg.

Low temperature pyrolysis units have not yet been constructed on full-scale unit size. However, pilot plant studies indicate the possible problems in utilization of oil due to its high viscosity which may cause problems in its transportation and burning.

➢ Pyrolysis units offer one major advantage, that is, lesser pollution of air as the air supply is lesser than the stoichiometric oxygen enquirement in incineration. Its running cost is also claimed to be lesser than incineration.

2.3.5 Methods under development :-

➢ Conversion to Biogas - Anaerobic digestion of the organic fraction

of Municipal solid waste is also feasible. The process produces a mixture of methane and carbon dioxide which may be used as fuel. The residue contains most of the plant nutrients, like nitrogen, phosphorus and potassium, and can be conveniently used as manure. The inorganic fraction has to be separately disposed off by land filling.

- Calorific value of the gas produced by this method is the same as that of the gas from digestion of sewage sludge. However, design criteria and economics of the process have to be properly established before the process can be considered for use by civic authorities.
- Conversion to Single Cell Protein - It is feasible to convert cellulytic fraction of municipal solid wastes to single cell protein which can be easily used as cattle feed. The product is known to be very rich in most of the essential amino acids.
- A detailed analysis of the process needs to be carried out so as to evaluate the economic feasibility of the process.
- Recycling and Reuse of Components - Various organisations have developed processes for segregation and reuse of solid waste components, such as paper, metals and glass. These have a larger application in developed countries where the proportion of these constituents in municipal solid waste is large. In India, most of these materials are reclaimed at the source itself and do not reach solid waste collection sites.

2.3.6 Observations :-

Considering the advantages and disadvantages of various methods of disposal of MSW none of the method is in position to provide considerable solution to the problem. Particularly in view of the huge quantum of MSW generated, lack of space, etc.

3. RESEARCH INITIATIVE
INNOVATIVE CONCEPT OF USE OF MSW.

3.1 INTRODUCTION :-

It is natural that any thing buried in the earth, gets converted into earth itself. The same principle applies to the MSW lying at dumping ground. MSW - dumped is subject to extensive chemical, physical and micro-biological processes - collectively called as decomposition. This process converts MSW into decomposed solid waste, new biomass, generates gases, contaminants in solution (leachate), heat, etc. The process of decomposition is most active during the first few years, but it may typically continue for several decades. The period of conversion varies from the type of MSW and its contents. For example the compostable matter, gets converted into soil within 3 months to one year. The other major component which is inert material generally ash, fine earth, debris, construction materials, etc..., gets disintegrated and becomes soil depending on the strength of its binding material. As regards glass, metal, plastic, etc., it takes long time may be hundreds of years to convert.

3.2 Innovative Concept of Use of MSW :-

Since the land fill method for disposal of MSW is adopted for the past several years in Deonar Dumping Ground, the organic matters in dumped MSW deposits must have been decomposed and got converted into soil. Keeping in mind this principle, Mr. S.S. Shinde, Dy. Municipal Commissioner, Municipal Corporation of Greater Mumbai, Mumbai, has thought of making such product which will consume the decomposed soil of MSW. And thus he visualised an innovative concept of making building bricks by using decomposed MSW Soil. He also tried to establish that the bricks made from decomposed MSW has following features:-

- Consumption of Huge quantity of MSW.
- Low capital investment.
- Employment generation.
- Environment friendly.
- Economically viable.

To examine the viability of this thought, since October 2002, three experiments have been carried out, at Deonar dumping ground. For carrying

out these experiments, screened MSW soil was obtained by taking trial pits at one of the corner in dumping ground.

3.3 Stages involved in carrying out experiment were as under : -

1) The total area has been inspected to fix the locations for pits then the quarrying of soil was done and kept for drying.
2) The dried soil then sieved.
3) Sample of soil sent to laboratory for soil investigation.
4) The soils from agriculture field were brought.
5) The pits were excavated for mixing & making clay.
6) The dumping ground sieved soil and agriculture field soil was mixed in various proportion and then put in pits, which was filled with water.
7) The mixing was done manually.
8) During the process of mixing, removed the material like plastic, stones, etc... which could not be segregated during sieving.
9) The above mixed material kept in pit for 24 hours for soaking.
10) After 24 hours the above mixed material got converted into mud which was brought out from pits and kept along sides for about 12 hours to increase its plasticity.
11) Then bricks/blocks were made from this mud.
12) These bricks/blocks were kept for sun drying.
13) After confirming that the blocks are well dried, the bhatti/kiln was arranged for burning of these bricks in cubical shape on platform prepared on the ground.
14) The bhatti was then encased to avoid heat loss by arranging already burnt bricks all around the periphery of the bhatti and by keeping 4" gap.
15) The 4" gap was filled by paddy foliage to keep the bhatti burning.
16) Then the bhatti was kept burning using paddy foliage/coal.
17) After burning bhatti was allowed to cool down and then it was opened.
18) On opening the bricks/blocks were tested as per I.S. Code 1077 in Municipal and V.J.T.I. Laboratories.

Experiment wise details of activities and resources used is as follows:

Sr. No.	Description	Experiment I	Experiment II	Experiment III
1	No. of bricks made	3800	1350	70000
2	MSW Soil collected from	5 locations	4 locations	10 locations
3	Quantity of MSW excavated.	25 T	18 T	540 T
4	Sieving up to grain size.	10 mm down	10 mm down	10 mm down
5	Quantity of graded soil found.	13 T	9 T	225 T
6	Quantity of non graded soil found.	12 T	9 T	315 T
7	Whether soil from agriculture field were brought.	Yes	No	Yes
8	Quantity of paddy foliage used.	50 kg	500 kg	15000 kg
9	Quantity of sea sand used.	25 kg	50 kg	800 kg
10	No. of labourers used.			
	i) For sieving of soil.	50	60	189
	ii) For mixing of soil.	6	6	282
	iii) For arranging Bhatti.	4	4	97
	iv) for other works.	10	18	
11	Machinery used.			
	i) J.C.B. for excavation.	6 hours	6 hours	18 hours
	ii) Dumpers for transportation.	10	12	185
	iii) Water tanker for water supply.	2	2	36

Sr. No.	Description	Experiment I	Experiment II	Experiment III
	iv) Electricity.	1 Halogen lamp	1 Halogen lamp	1 Halogen lamp
12	Quantity of salt used.	Nil.	25 kg	Nil.
13	Type of coal used.	Nilgai	Chandrapur	Chandrapur
14	Quantity of coal.	500 kg	1000 kg	5800 kg
15	Quantity of water used.	4000 lit.	3000 lit.	180000 lit.
16	No. of pits excavated for mixing of soil.	2	6	10
17	Location of pits in Deonar Dumping Ground.	Near Conference Hall open ground.	Near Conference Hall open ground.	Open plot in Bulldozer garage and near bldg.
18	% of agriculture soil.	10% to 15%	Nil	10%
19	Mixing of soil.	Thoroughly	Thoroughly	Thoroughly
20	Number of laborers deployed for mixing of soil.	One labour	Two labours in each pit.	2 labourers in each pit.
21	The mud was kept in the said pits for	24 hours	24 hours	24 hours
22	To increase plasticity of mud it was kept along pit for	12 hours	12 hours	10 to 12 hours
23	Blocks/bricks were sun dried for.	4 to 5 days.	7 to 8 days.	4 to 5 days.
24	Blocks/bricks were dried from other side for.	2 to 3 days.	2 to 3 days.	15 days.
25	The size of Kiln in feet. L*W*H	10'x8'x8'	20'x10'x5'	20'x40'x12'

Sr. No.	Description	Experiment I	Experiment II	Experiment III
26	Encasing of Kiln to avoid heat loss.	Ground was leveled by soil and also by arranging already burnt bricks. All around the periphery of bhatti by keeping 4" gap from Bhatti.	Arranging two layers of already burnt bricks for bottom platform and by arranging already burnt bricks all around the periphery of Bhatti by keeping 4" gap from layers.	Arranging two layers of already burnt bricks for bottom platform and by arranging already burnt bricks all around the periphery of Bhatti by keeping 4" gap from layers.
27	The Kiln was burn with paddy foliage for	6 days	10 days	12 days
28	The Kiln was allowed to cool down for	2 days	4 days	6 days
29	Period for carrying out this whole process.	25 days.	30 days.	60 days
30	Visual physical properties of bricks on opening the Kiln.			
	i) Color	Red	Red	Red
	ii) Shape	Partly bent due to excess burning	Partly bent due to excess burning	Good
	iii) Sound	After striking each other it creates wringing sound.	-	After striking each other it creates wringing sound.

Sr. No.	Description	Experiment I	Experiment II	Experiment III
31	Observations of bricks in kiln	Top layers are of brittle nature. Bottom layer was seen as normal bricks with normal edges.	Most of the bricks are brittle in nature.	Bricks are in good conditions. Edges are good.
32	Skilled persons in this field were brought from village.	Wada	Neral, Metheram, Karjat	Usgaon, Vasai

Experiement No. 1 Details of samples along with soil used

Sample No.	Mark	Quarried up to depth in metre	Quarried out from dumping ground in MT	Fine material after sieving in MT	Agricultural soil added in %
1	No Mark	1.5	6	3	10
2	1 Hole	1.5	6	3	10
3	2 Holes	1.5	5	3	10
4	3 Holes	1.5	5	2	5
5	KBK	1.5	4	2	5

Experiement No. 1 Test report as per IS Code 1077

Sample No.	Mark	Municipal Laboratory		V.J.T.I. Laboratory	
		% Water Absorption	Compressive strength kg\cm^2	% Water Absorption	Compressive strength kg\cm^2
1	No Mark	13.82	33.10	17.90	70.50
2	1 Hole	19.80	39.00	18.50	75.90
3	2 Holes	20.15	24.90	18.40	51.50
4	3 Holes	17.36	33.50	19.82	64.00
5	KBK	22.40	20.70	18.20	66.00

Ambient air quality study was carried out by MPCB Officers for 6 hours. From the result, it was felt that burning of bhatti has not produced any harmful elements in the air.

Ambient Air Quality Monitoring

Sample Received from : Sub Regional Office Mumbai - II
Sample Collected on : 16.11.2002
Sample Received On : 18.12.2002
Sample Details JVS NO. / Station : Deonar Dumping Ground

Date of sampling	Time of sampling	SO2	NOx	NH3	RSPM	SPM	Pb
16.11.02	11.15 AM	8.0	69.0	-	68.0	-	-
	15.19 PM	4.0	33.0	-	68.0	-	-

Sample Collected by : SRO Mumbai - II
Name, Designation & Seal No. : B. P. & P. P. Jagtap (C. O.)

Photo 3.1 : While excavating pit for mixing.

Photo 3.2 : Sun drying of moulded bricks

Photo 3.3 : While arranging kiln.

Photo 3.4 : While burning kiln.

Photo 3.5 : While taking ambient air samples.

Photo 3.6 : While opening kiln.

Photo 3.7 : While testing the brick at site.

Photo 3.8 : The visit of Municipal Commissioner to Site

On completion of first experiment and testing of burnt bricks, it was felt that from the mixture of soil drawn from the dumping ground and agriculture soil, the bricks can be made. However, our intention since beginning was to make bricks by use of 100% soil drawn from the dumping ground. Therefore, it was decided to conduct second experiment by use of only soil drawn from dumping ground of which details are as follows :-

Experiement No. 2 Details of samples along with soil used

Sample No.	Mark	Quarried up to depth in metre	Quarried out from dumping ground in MT	Fine material after sieving in MT	Agricultural soil added in %
1	No Mark	1.5	4	2	Nil
2	1 Hole	1.5	5	2	Nil
3	2 Holes	1.5	3	1.5	Nil
4	3 Holes	1.5	3	1.5	Nil
5	4 Holes	1.5	3	1.5	Nil
6	5 Holes	Gr. Level	3	1.5	Nil

Photo 3.9 : Preparing pit for mixing.

Photo 3.10 : While sun drying the bricks.

Photo 3.11 : While arranging the brick kiln.

Photo 3.12 : While arranging the brick kiln.

Photo 3.13 : While arranging the kiln.

Photo 3.14 : While arranging the kiln.

Photo 3.15 : While arranging the kiln.

Photo 3.16 : While arranging the kiln.

Photo 3.17 : While igniting the kiln.

Photo 3.18 : While burning the kiln.

Photo 3.19 : While opening the kiln.

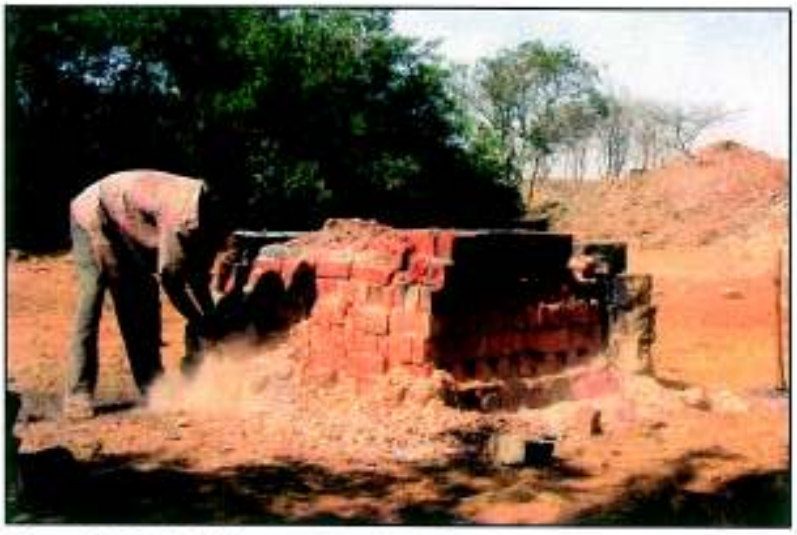


Photo 3.20 : While opening the kiln.

Photo 3.21 : On opening the kiln making observations.

Photo 3.22 : While making observations of burnt brick.

From Experiment No.2, we could not get any brick in proper shape as most of the bricks were brittle and crumbling at site itself. Therefore, testing of these bricks could not be done. Again to see the viability of making large numbers of bricks by mixture of soil drawn from the dumping ground and agriculture soil, it was decided to conduct third experiment of about one lakh bricks and the details are as follows:

Experiement No. 3 Details of samples along with soil used

Sample No.	Mark	Quarried up to depth in metre	Quarried out from dumping ground in MT	Fine material after sieving in MT	Agricultural soil added in %
1	VBV1	4	50	20	10
2	BMC	4	50	20	10
3	3	4	60	24	10
4	4	4	60	24	10
5	5	4	55	22	10
6	6	4	60	24	10
7	7	4	45	18	10
8	8	4	50	20	10
9	9	4	50	20	10
10	10	4	60	24	10

It is to mention that, while conducting third experiment, there was a strike called by Truck Owners. Therefore, required agriculture soil could not be transported at site. However, soil (not agricultural soil) which was brought to the dumping ground as part of MSW garbage has been used for this experiment. Therefore, in this experiment also, we could not get the required quality bricks. On analyzing, it was felt that may be due to improper heating and also due to quality of soil used, bricks could not be made of the required standard.

Photo 3.23 : Completed kiln of experiment No. 3 .

While conducting third experiment, we came across number of experts and the people who are concerned with the problem created by MSW dumped at dumping ground.

During these experiments, number of people encouraged us, particularly, the then Municipal Commissioner, who visited and appreciated the work being carried out.

The outcome of these experiments and encouragements from all the concerned, a feeling is created that we must continue to work on above lines and provide a solution to the one of the major problem of the Urban area.

4. LABORATORY WORK

4.1 Introduction :-

From the outcome of first three experiments, it was felt that, further detail study is required to establish that, from the mix of MSW soil and agricultural soil, the bricks of required standard can be made. For these three experiments we have already spent Rs. 1,45,135/-, out of which some money was taken on loan. For detail study, fund is required thereby we were in search for financial support.

Meanwhile we came to know that one of the Organization of MMRDA viz. MMR Environment Improvement Society provides financial assistance for the research work carried out in the sector of environment protection. Therefore, it was decided to make a formal application to the MMR- Environmental Improvement Society for seeking grant. Then question came, to whose account such money shall be drawn and it was felt that it would be easier to operate, if money is drawn on account of "All India Local Self Government" for which AILSG has also agreed. Team formed and application made to MMR Environment Improvement Society.

The team members are :-

1. Shri G.B. Chaudhari, Asst. Professor, V.J.T.I. Team Leader
2. Shri A.K. Jain, Sr. Advisor, AIILSG
3. Shri S.S. Shinde, Dy. Municipal Commissioner, M.C.G.M.
4. Dr. P.P. Bhave, Lecturer, Civil Engineering Dept., VJTI
5. Shri A.Y. Mukadam, Executive Engineer, M.C.G.M. (Retd.)
6. Shri Pramod Kalme, Civil Engineer

(7. Dr. M. G. Karmarkar, Associate Professor, G. S. Medical Collage, K.E.M. Hospital, Parel, Mumbai has helped to carry out Microbiological Analysis.)

The activities identified in the proposal were as follows :-

- Taking 20 trial pits up to 4 m. depth at various locations in Deonar Dumping Ground and drawing samples of soil at every 1 Mt. depth.
- Taking 5 trial bores up to 10 m. depth at various locations in Deonar dumping ground and drawing undisturbed samples.
- Analysing samples of soil and leachate drawn, for engineering and chemical properties.
- Preparing 20 mix designs with various types of soil sample in

various proportions in the laboratory and testing of same.

- Manufacturing of 6000 brick samples from various mixes of MSW soil and agricultural soil.
- Carrying out various test as per IS 1077 on bricks.
- Preparing research report.

Scope of research work

- Study the engineering and chemical properties of the MSW soil and brick clay / agricultural soil.
- Prepare mix designs for making brick from mix of MSW soil and agricultural soil.
- Suggest the mixes for making bricks of required standard in which maximum quantity of MSW could be used.
- Manufacturing bricks by using appropriate mixes.
- Ascertain the fulfillment of prescribed standard by such brick.
- To suggest further course of action.

After series of meetings and presentation before the members of MMR Environment Improvement Society, the acceptance of proposal was received in the month of February 2004 and thereafter work has started.

4.2 SAMPLING :-

As a first step to start research work, it was decided to collect the samples of MSW soil from Deonar dumping ground and brick clay/ agricultural soil from various places of brick manufacturing sites. The samples of MSW were collected by taking trial pits and trial bores,

Photo 4.1 : Aerial view of Deonar dumping ground

Photo 4.2 : Aerial view of Deonar dumping ground

Photo 4.3 : Aerial view of Deonar dumping ground

Photo 4.4 : Aerial view of Deonar dumping ground

4.2.1 Trial Pits :-

Trial pits were located in such a way so that they are spaced evenly through out the dumping ground area. Deonar dumping ground, which is a huge land, (about 70 Hectares) divided in twenty portions and in each portion, one trial pit of 4m x 4m x 4m depth was taken. In each trial pit, for each one metre depth, one sample of one cubic feet MSW was collected. Similarly, wherever found, the leachate samples were also taken.

To get the wet weight of each one cubic feet of MSW samples collected from trial pits, at each metre depth i. e. for 0 to 1m, 1 to 2m, 2 to 3m & 3 to 4m, were immediately weighed at site. Thereby, in all 80 numbers of MSW samples were collected from 20 trial pits. These samples were sun dried at site and later on sieved with 10mm size sieve, to segregate 10 mm down and above size material. After segregating, both these materials were weighed separately and transported to Soil Mechanics Laboratory V.J.T.I. for further analysis. Along with it, some samples were collected in sterilised glass tube and immediately transported for microbiological analysis at G.S. Medical College, K.E.M. Hospital, Parel, Mumbai. In addition to above, from every one metre depth of trial pit, 15 numbers of one cubic feet of 10mm down size screened MSW was separately collected and bagged. Thereby, from each trial pit, 60 numbers of 10mm down size screened MSW was collected and bagged.

4.2.2 Trial Bore :-

Along with the trial pits, to get the depth and other details of MSW dumped at dumping ground, 5 trial bores were taken by appointing a geotechnical rotary drilling contractor. For taking these bores, the area of dumping ground was divided into five even parts. While drilling bores, the undisturbed samples of MSW were collected in 4" diameter and 2 feet long M.S. tubes. Borehole samples were collected from ground level upto 10 meters depth. From bore log it is found that generally the depth of MSW is upto 7 to 9 meters from present ground level. Below 7 to 9 meters depth, generally, marine clay exists. Even in each 2 feet long undisturbed samples(UDS), the recovery of actual sample was much less and it is due to presence of cloth, plastc, tyres, etc... which obstruct the collection of sample.

These undisturbed samples collected were transported to Soil Mechanics Laboratory, V.J.T.I. for further engineering and environmental analysis.The Leachate, samples were also collected, where ever it was available. Details of bore holes is as follows:-

Bore No	No. of samples
1	10
2	9
3	11
4	10
5	6

On 10.4.2004, the Members of MMR Environment Society had visited the site, appreciated the work being carried out and gave some suggestions.

Photo 4.5 : While excavating trial pit.

Photo 4.6 : While inspecting trial pit.

Photo 4.7 : Excavated trial pit.

Photo 4.8 : Excavated trial pit.

Photo 4.9 : While inspecting trial pit.

Photo 4.10 : During visit to dumping ground.

Photo 4.11 : During visit to dumping ground.

Photo 4.12 : During visit to dumping ground.

Photo 4.13 : 10mm size seive used for separation of MSW.

Photo 4.14 : While taking the trial bores.

Photo 4.15 : While inspecting the trial bore.

Photo 4.16 : Of trial pit no. 3.

Photo 4.17 : While taking the trial bore.

Photo 4.18 : While discussing further course of action.

4.2.3 Brick Making Soil :-

Various types of agricultural soil is used for making bricks. The samples of soil from which the normal bricks are made were collected from the locations of brick making sites in four villages of Thane District. In these cases mixture of black cotton soil and yellow soil is used. Two types of agricultural soil samples were collected from each sites; one sample of black cotton soil and second of yellow soil. Similarly brick clay i.e. mixture of above two soils and other additives like paddy foliage etc. was also collected.

Details are as follows :-

Village	No. of Samples Collected	
	Agricultural Soil	Brick Clay
Varai Pargaon	4	1
Gothivali	5	1
Chana	5	1
Taloja	3	1

4.2.4 Fly Ash :-

In the meantime, we felt that as like, municipal solid waste, fly ash is also generated in huge quantity at all the thermal power station and its disposal is a major problem. As like municipal solid waste, the fly ash is also causing serious threat to the environment by polluting the water, air etc. Number of experiments have been carried out to make bricks from the fly ash by the compression and other methods. We have also decided to experiment the use of fly ash along with MSW for making the bricks. To get the more information on fly ash, we visited the Tata Thermal Power Station, Trombay on 26.6.2004 and on 23.1.2005, Koradi Power Station, MSEB Nagpur. The samples of fly ash collected are as follows.

F1 : Fly ash from Tata Thermal Power Station

F2 : Fly ash from Reliance Thermal Power Station, Dahanu.

All samples collected were transported simultaneously to the laboratories for carrying out various analysis. The analysis were basically of four types as under,

- Engineering properties
- Chemical/environmental properties
- Micro-biological analysis

- Preparation of Mix design

Analysis of Engineering properties were carried out in Soil Mechanics Laboratory, Chemical and environmental properties at Environmental Engineering Laboratory at V.J.T.I., Mumbai. Micro-biological analyses at G.S. Medical College, K.E.M. Hospital, Parel, Mumbai.

4.3 Engineering Properties :-

To ascertain various engineering properties of samples following tests were carried out:-

- Sieve analysis
- Atterberg Limits
- Standard Proctor Compaction Test (SPCT)
- Air dry loose density

4.3.1 Engineering properties of 10 mm down size MSW Soil Sample :-

The 10 mm down size MSW soil samples drawn from trial pit were seived at dumping ground and then brought to VJTI Laboratory for further analysis. The details of engineering properties of 10 mm down size MSW soil is as follows :-

Trial Pit	Sieve Analysis in %			Loose dry density gm/cc	Atterberg Limits in %			S.P.C.T.	
	10 to 4.75 mm	4.75 to 0.075 mm	< 0.075 mm		L.L.	P.L.	S.L.	o.d.d. gm/cc	o.m.c. %
1	29.90	66.20	3.90	0.674	43	26.2	24.2	1.618	15.8
2	32.50	63.78	3.72	0.434	Non-Plastic			1.307	29.5
3	48.45	48.30	3.25	0.240	Non-Plastic			1.168	32.0
4	29.16	61.50	9.34	0.382	Non-Plastic			1.277	26.0
5	24.65	71.75	3.60	0.436	Non-Plastic			1.502	21.4
6	31.30	52.90	6.80	0.432	42	31.25	19.23	1.608	21.2
7	29.13	66.78	4.09	0.424	Non-Plastic			1.050	32.0
8	41.48	52.28	6.24	0.304	Non-Plastic			1.252	27.5
9	33.78	58.60	7.62	0.255	Non-Plastic			1.250	26.0

Trial Pit	Sieve Analysis in %			Loose dry density gm/cc	Atterberg Limits in %			S.P.C.T.	
	10 to 4.75 mm	4.75 to 0.075 mm	< 0.075 mm		L.L.	P.L.	S.L.	o.d.d. gm/cc	o.m.c. %
10	31.85	64.33	3.82	0.436	Non-Plastic			1.328	26.5
11	33.35	62.73	3.92	0.423	Non-Plastic			1.217	31.6
12	39.70	53.50	6.80	0.357	Non-Plastic			1.276	28.2
13	32.40	63.00	4.60	0.563	Non-Plastic			1.348	24.0
15	20.55	75.53	3.92	0.600	Non-Plastic			1.489	22.0
16	33.00	61.93	5.07	0.486	Non-Plastic			1.476	20.0
17	21.73	75.37	2.90	0.437	Non-Plastic			1.352	24.0
18	29.33	70.00	0.67	0.551	Non-Plastic			1.300	26.3
19	25.56	72.19	1.65	0.436	Non-Plastic			1.556	19.0
20	24.52	74.67	0.82	0.481	Non-Plastic			1.548	20.5

* L.L. - Liquid Limit, P.L. - Plastic Limit, S.L. - Shrinkage Limit, o.d.d. - optimum dry density, o.m.c. - optimum moisture content. S.P.C.T. - Standard Proctor Compaction Test.

From above it indicates that :

- In MSW soil, the amount of finer material i.e. less than 0.075 mm size is very less.
- The MSW soil is non-plastic material i.e. non-cohesive in characteristics.
- The optimum dry density of MSW soil ranges between 1.005 gm/cc and 1.618 gm/cc.

4.3.2 Engineering Properties of agricultural soil sample :-

Conventionally, the bricks are made by use of agricultural soil removed from the agricultural field. The brick clay is formed generally by mixture of agricultural and yellow soil. The details of engineering properties of agricultural soil sample collected from various brick making sites is as follows :-

Location - Varai Pargaon Village

Sample No.	Sieve Analysis in %			Atterberg Limits			S.G.	S.P.C.T.	
	10 to 4.75 mm	4.75 to 0.075 mm	< 0.075 mm	L.L. %	P.L. %	S.L. %		o.d.d. gm/cc	o.m.c. %
1	3.4	24.6	72.0	49.5	22.31	17.0	2.542	1.620	21.5
2	4.8	41.0	54.2	-	N.P.	-	2.479	1.678	17.8
3	3.0	16.4	80.6	47.5	24.48	16.0	2.547	1.630	21.7
4	0.8	13.4	85.8	48.0	23.70	17.3	2.564	1.650	21.7
5	1.6	8.2	90.2	48.0	23.08	-	2.553	1.656	21.6

Location - Gothivali Village

Sample No.	Sieve Analysis in %			Atterberg Limits			S.G.	S.P.C.T.	
	10 to 4.75 mm	4.75 to 0.075 mm	< 0.075 mm	L.L. %	P.L. %	S.L. %		o.d.d. gm/cc	o.m.c. %
1	1.34	14.12	84.54	48.5	22.70	17.9	2.553	1.616	21.60
2	1.28	17.02	81.70	47.5	22.86	18.1	2.542	1.700	18.20
3	4.18	34.84	60.98	-	N.P.	-	2.469	1.402	23.00
4	3.88	15.32	80.80	-	N.P.	-	2.532	1.695	17.00
5	7.98	21.68	70.34	47.8	22.84	17.2	2.546	1.625	19.25
6	1.66	14.50	83.34	49.5	21.96	19.8	2.459	1.390	22.50

Location - Chana Village

Sample No.	Sieve Analysis in %			Atterberg Limits			S.G.	S.P.C.T.	
	10 to 4.75 mm	4.75 to 0.075 mm	< 0.075 mm	L.L. %	P.L. %	S.L. %		o.d.d. gm/cc	o.m.c. %
1	8.0	40.8	51.29	44	25.87	16.9	-	1.677	19
2	10.8	67.8	21.40	45	25.87	16.4	-	-	-
3	5.6	30.8	58.60	46	29.33	15.6	-	1.604	24
4	4.0	20.2	72.83	50	26.35	15.5	-	-	-
5	9.8	34.6	50.60	45	25.85	16.4	-	-	-
6	8.2	34.4	53.40	46	25.95	16.6	-	-	-

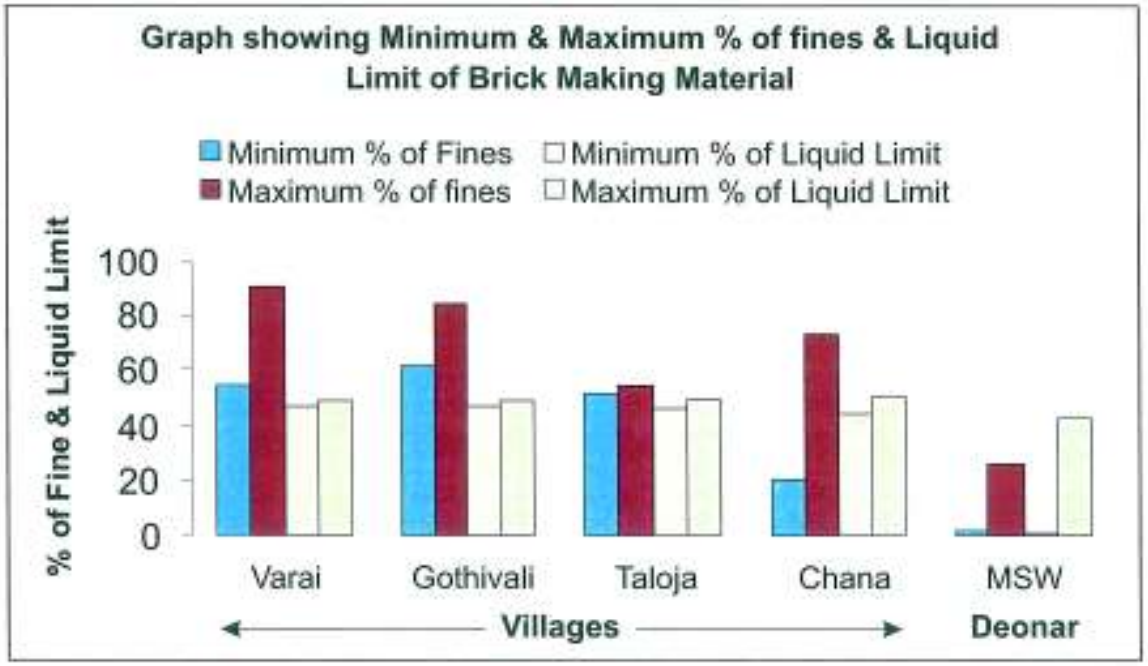
Location - Taloja, Ova. Village

Sample No.	Sieve Analysis in %			Atterberg Limits			S.G.	S.P.C.T.	
	10 to 4.75 mm	4.75 to 0.075 mm	< 0.075 mm	L.L. %	P.L. %	S.L. %		o.d.d. gm/cc	o.m.c. %
1	1.8	47.0	51.2	46	24.60	19.2	-	1.706	20.0
2	8.0	36.4	53.6	49	26.85	16.3	-	-	-
3	11.0	42.4	46.6	46	31.90	16.9	-	-	-
4	8.8	39.6	51.6	48	28.95	16.3	-	1.652	15.5

* L.L. - Liquid Limit, P.L. - Plastic Limit, S.L. - Shrinkage Limit, o.d.d. - optimum dry density, o.m.c. - optimum moisture content. S.G. - Specific Gravity, S.P.C.T. - Standard Proctor Compaction Test. N.P. - Non Plastic

From above analysis of agricultural soil and MSW following observation are made.

Village	Varai	Gothivali	Chana	Taloja	MSW
Minimum % of Fine	54.2	60.98	21.40	46.6	2.80
Maximum % of fine	90.2	84.54	72.83	53.6	27.92
Minimum % of Liquid Limit	47.5	47.50	44.00	46.0	N.P.
Maximum % of Liquid Limit	49.5	49.50	50.00	49.0	43.00



From above tests, it is indicated that :

- In agricultural soil the amount of finer material i.e. less than 0.075 mm in size ranges between 21.4% and 90.2%.
- The agricultural soil is a plastic material i.e. cohesive in characteristic.
- The optimum dry density of agricultural soil ranges between 1.4 gm/cc and 1.70 gm/cc.

4.4 Chemical Properties :-

To ascertain various chemical properties of the samples following tests were carried out.

i) pH value
ii) % T.O.C. (Total Organic Carbon) - i.e. loss on ignition.
iii) Soluble Chlorides
iv) Soluble Sulphates
v) Soluble Phosphates,
vi) Soluble Na (Sodium),
vii) Soluble K (Potassium),
viii) % SiO_2 (Silica)
ix) % Al_2O_3 (Alumina)
x) % Fe_2O_3 (Ferric Oxide)
xi) % CaO (Calcium Oxide)

4.4.1 Chemical analysis of MSW : -

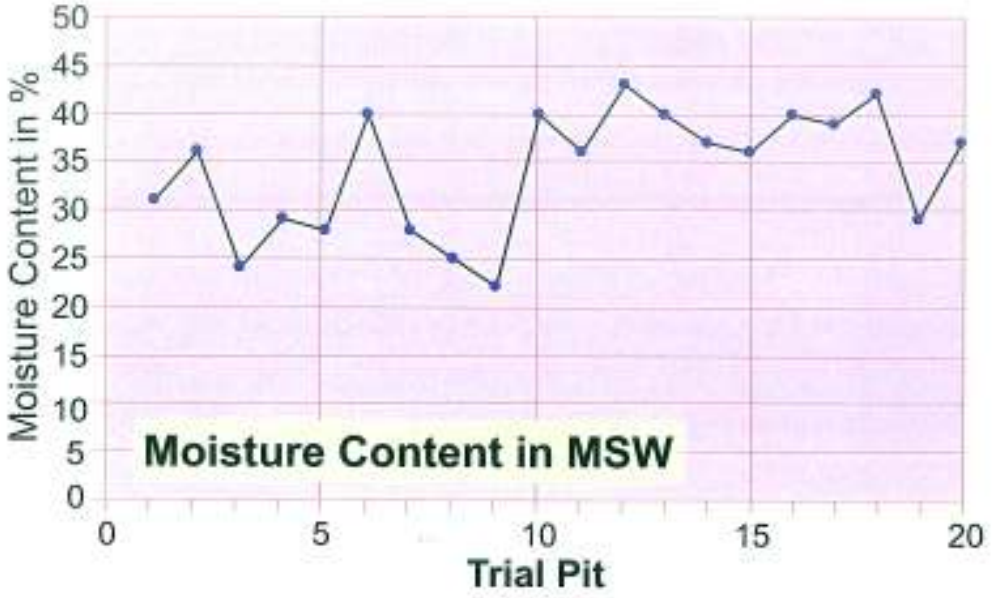
10 mm down grain size MSW soil were used for chemical analysis and the results are as follows :-

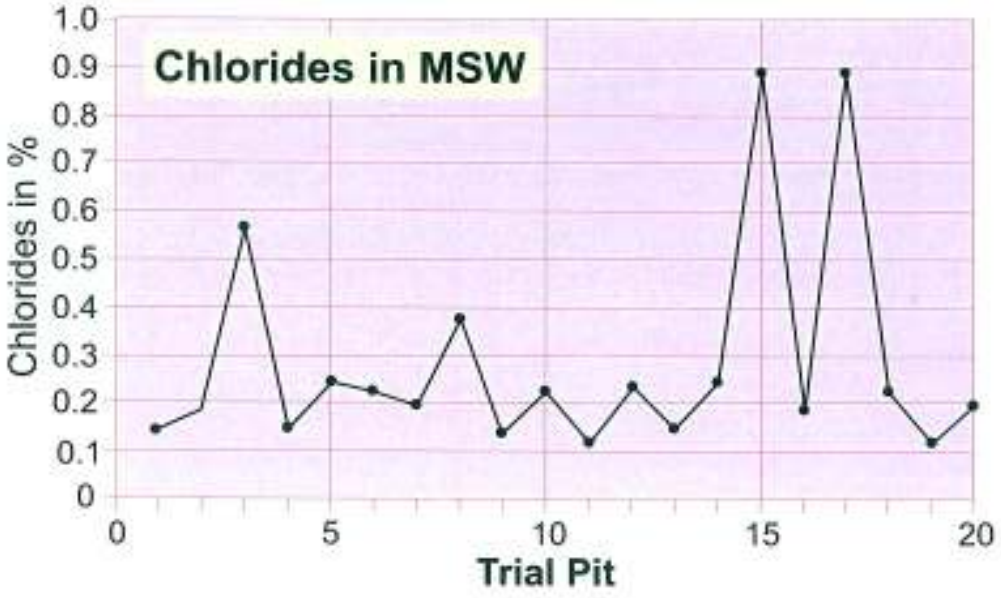
Trial Pit	pH	Bulk Density gm/cc	M.C.	Chlorides %	Sulphates %	Phosphates %	Sodium %	Potassium %	T.O.C %
1	7.7	936	31	0.14	0.52	0.98	0.39	0.63	7.51
2	7.7	583	36	0.18	0.38	0.52	0.53	0.58	8.17
3	7.7	459	24	0.56	0.71	1.17	0.34	0.96	11.97
4	7.8	565	29	0.14	0.77	0.65	0.75	0.45	9.07
5	7.8	600	28	0.24	0.95	0.35	0.40	0.64	8.14
6	8.3	759	40	0.22	0.30	0.49	0.79	0.80	8.22

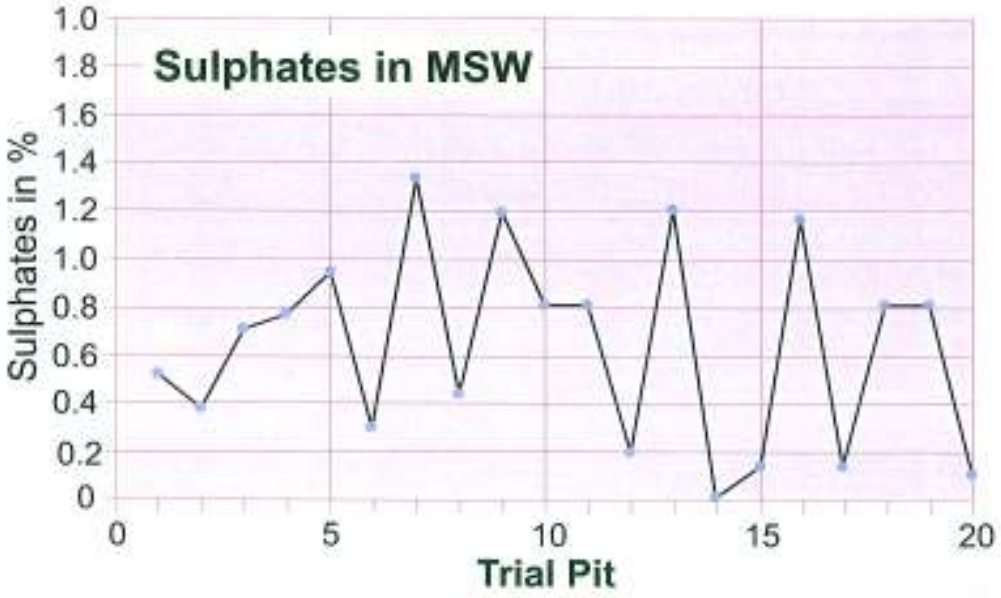
Trial Pit	pH	Bulk Density gm/cc	M.C.	Chlorides %	Sulphates %	Phosphates %	Sodium %	Potassium %	T.O.C %
7	7.7	742	28	0.19	1.34	0.99	0.77	0.44	11.12
8	8.0	442	25	0.37	0.44	1.18	0.68	0.71	10.18
9	7.9	406	22	0.13	1.20	1.41	0.90	0.41	11.51
10	7.6	715	40	0.22	0.81	1.51	0.77	0.54	8.68
11	7.7	609	36	0.11	0.81	0.95	0.63	0.54	9.14
12	7.3	486	43	0.23	0.20	1.58	0.69	0.63	10.33
13	7.8	786	40	0.14	1.21	1.02	0.90	0.85	9.64
14	7.8	768	37	0.24	0.01	3.80	0.99	0.75	9.47
15	8.3	750	36	0.89	0.14	1.70	0.94	0.72	9.32
16	7.7	689	40	0.18	1.17	1.30	0.71	0.60	8.14
17	7.8	653	39	0.89	0.14	1.13	0.74	0.68	8.22
18	7.8	830	42	0.22	0.81	0.77	0.81	0.53	8.29
19	7.7	662	29	0.11	0.81	6.94	0.69	0.63	9.87
20	7.6	706	37	0.19	0.11	4.26	0.99	0.75	11.22

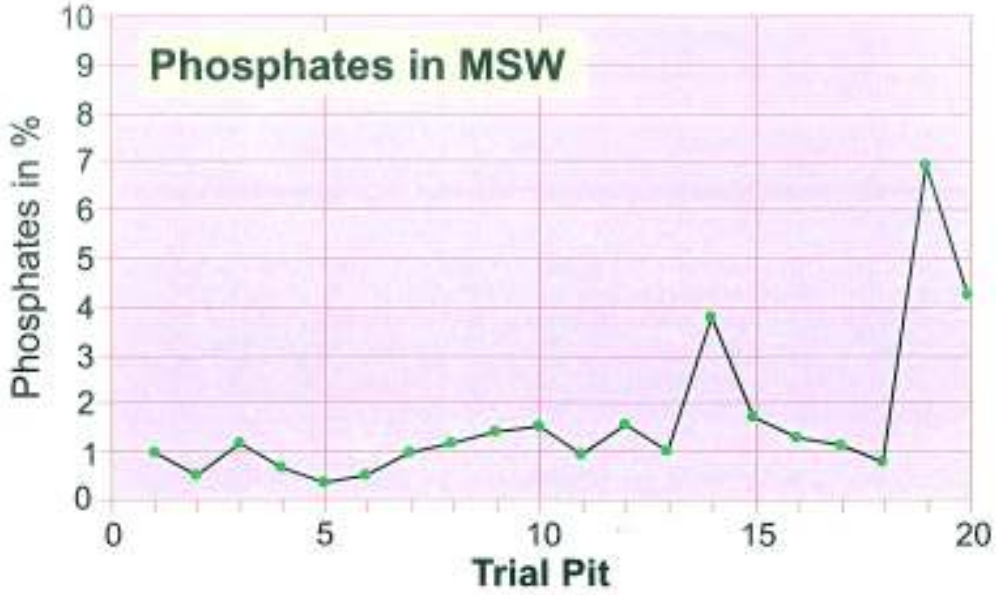
M.C. - Moisture Content, T.O.C. - Total Organic Carbon

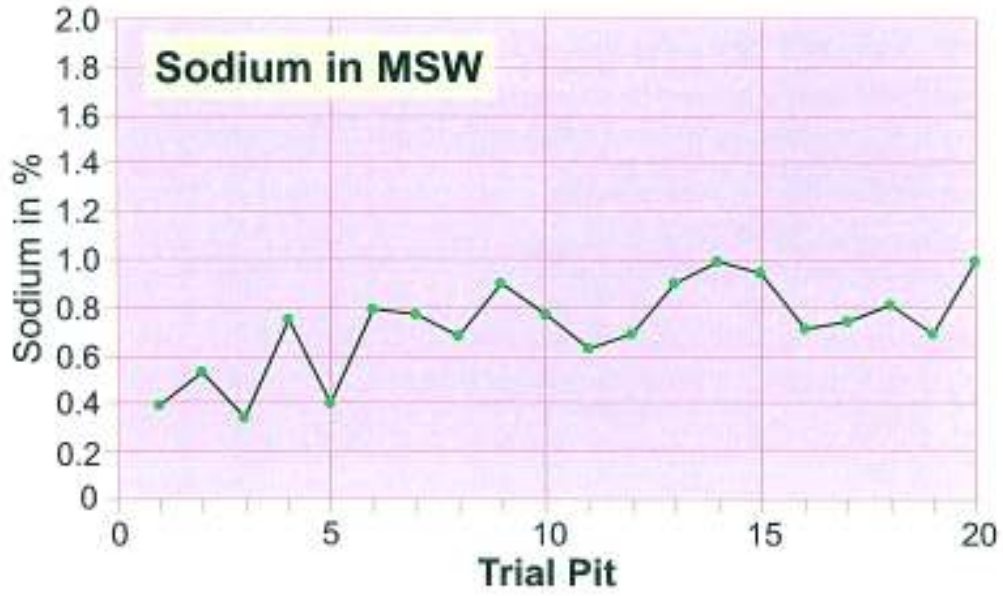
The graphical presentation of various parameters as per locations of Trial Pits is as follows :-

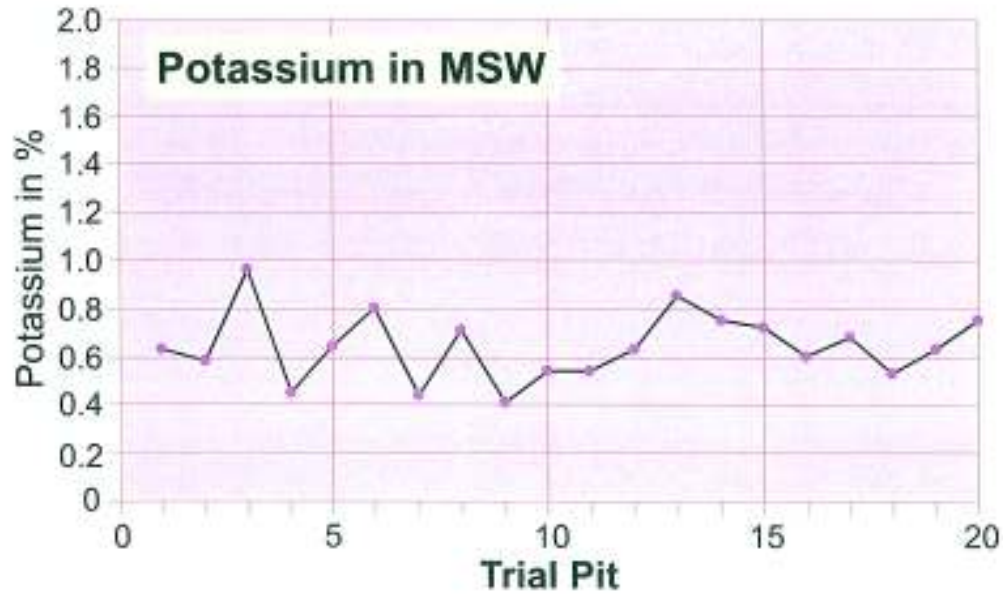

Moisture Content in %
50
45
40
35
30
25
20
15
10
5
0
0
5
10
15
20
Trial Pit
Moisture Content in MSW


Chlorides in %
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
Trial Pit
Chlorides in MSW


Sulphates in %
1.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0
5
10
15
20
Trial Pit
Sulphates in MSW


Phosphates in MSW
Phosphates in %
Trial Pit
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20

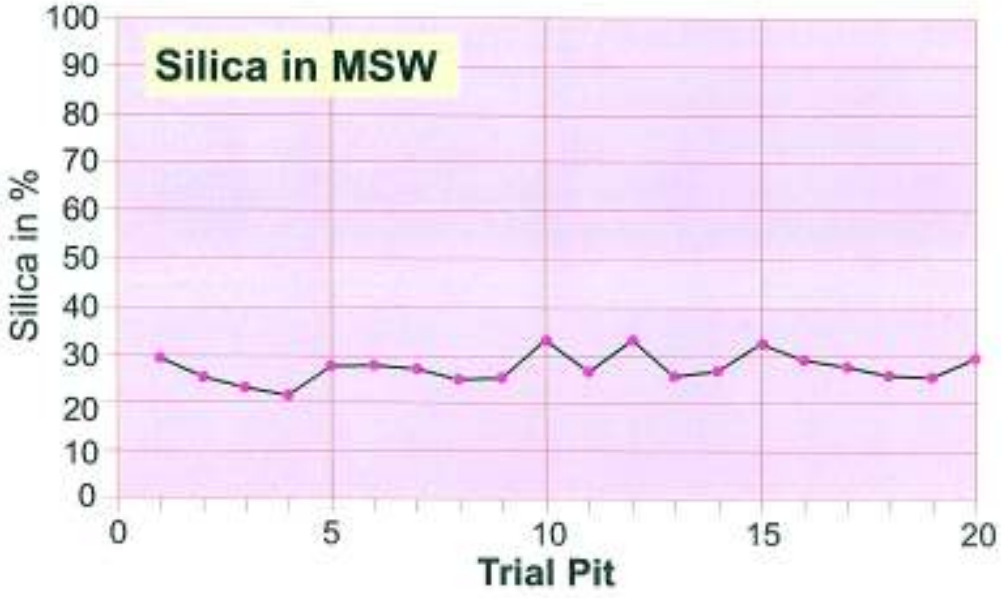

Sodium in MSW
Sodium in %
Trial Pit
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
0
5
10
15
20

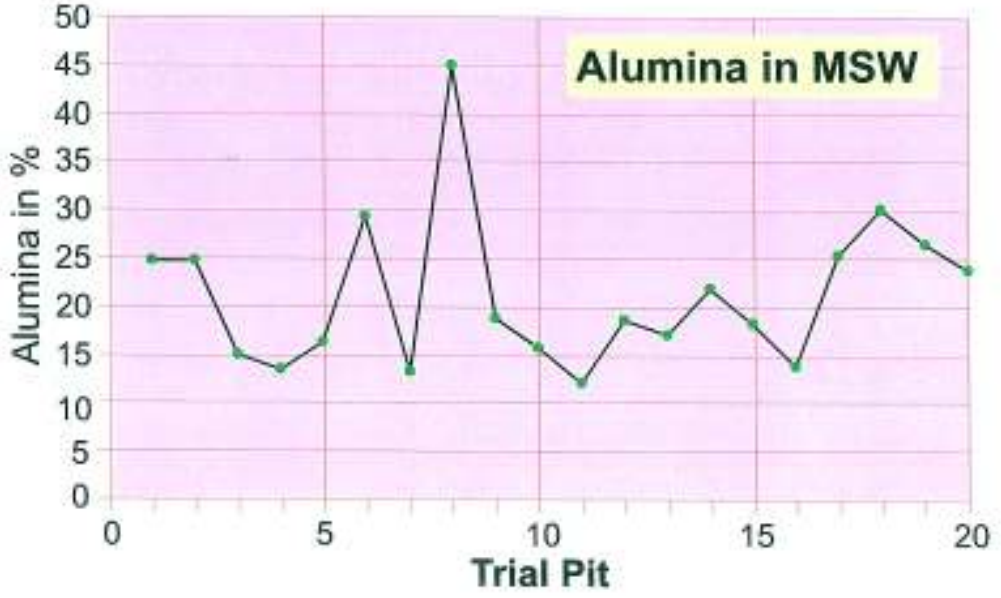

Potassium in MSW
Potassium in %
Trial Pit
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
0
5
10
15
20

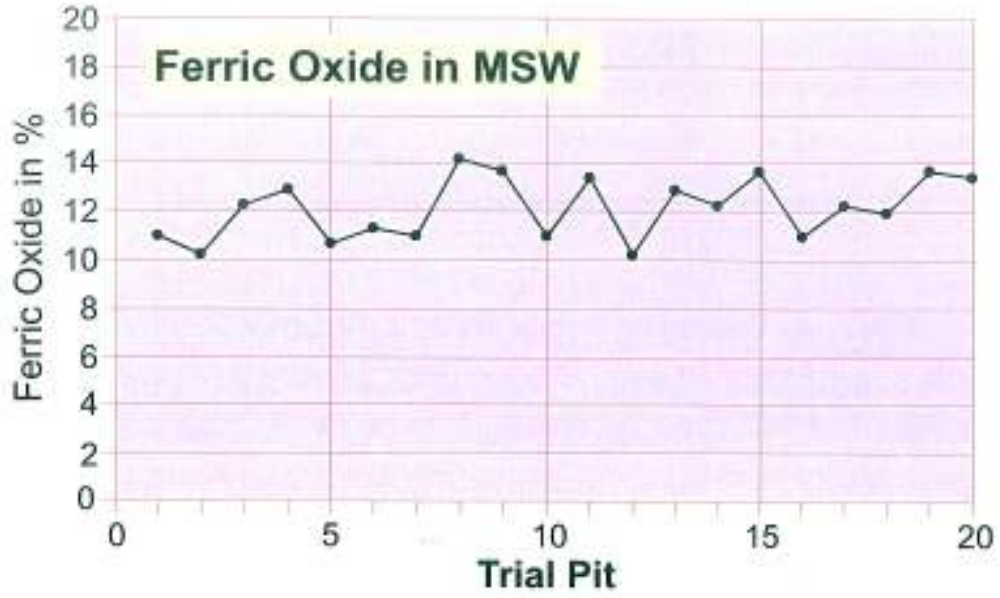
The main component of any soil is Silica, Alumina, Ferric Oxide and Calcium Oxide which were also analysed for MSW samples drawn from Trial Pits and the results are as follows :-

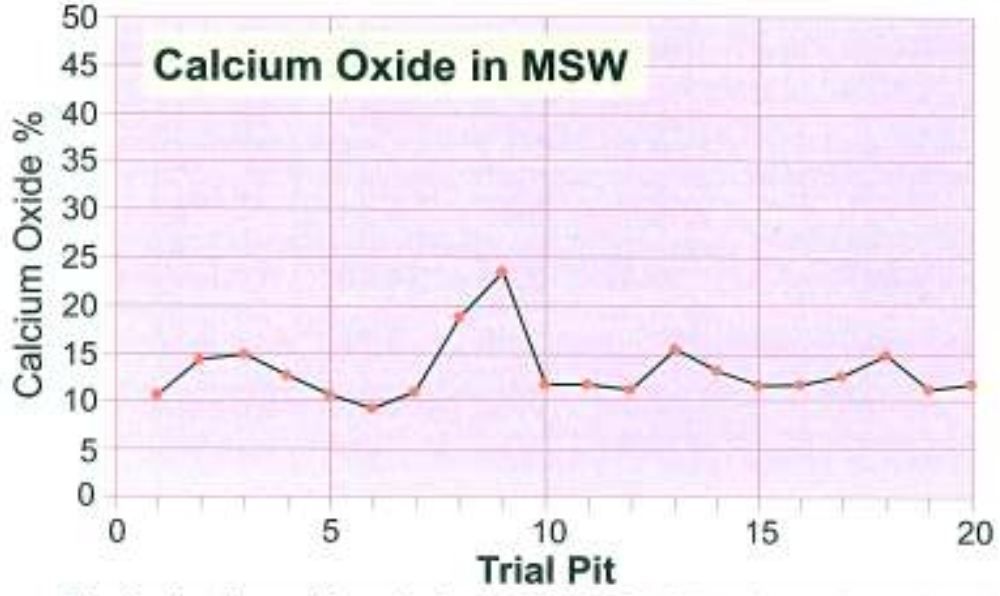
Trial Pit	Silica %	Alumina %	Ferric Oxide %	Calcium Oxide %
1	29.02	11.16	11.02	10.65
2	25.12	11.21	10.22	14.30
3	23.06	6.78	12.29	14.86
4	21.36	6.07	12.93	12.62
5	27.40	7.34	10.70	10.65
6	27.68	13.25	11.34	9.25
7	26.98	6.01	11.02	10.93
8	24.74	20.44	14.21	18.78
9	25.14	8.51	13.73	23.55
10	33.04	7.09	11.02	11.78
11	26.46	5.45	13.41	11.78
12	33.12	8.44	10.22	11.22
13	25.50	7.75	12.93	15.42
14	26.60	9.87	12.30	13.18
15	32.40	8.21	13.73	11.65

Trial Pit	Silica %	Alumina %	Ferric Oxide %	Calcium Oxide %
16	28.98	6.22	11.02	11.78
17	27.40	11.45	12.29	12.62
18	25.72	13.66	11.98	14.86
19	25.24	11.99	13.73	11.22
20	29.20	10.73	13.41	11.78









Similarly the undisturbed samples of MSW drawn from boreholes were also analysed for it's chemical properties which is as follows :- (10mm down MSW soil)

BH/ UDS	Depth in meter	pH	T.O.C. %	Chlo-rides %	Sulph-ates %	Phos-phate %	Sodi-um %	Pota-ssium %
1/1	0 to 1	7.2	-	0.07	0.10	-	-	-
1/2	2 to 3	7.4	-	0.11	0.13	-	-	-
1/3	3 to 4	7.3	8.52	0.21	0.21	-	-	-
1/4	4 to 5	7.4	9.50	0.12	0.21	-	-	-
1/5	5 to 6	7.2	-	0.13	0.15	-	-	-

BH/ UDS	Depth in meter	pH	T.O.C. %	Chlo-rides %	Sulph-ates %	Phos-phate %	Sodi-um %	Pota-ssium %
1/6	6 to 7	7.2	-	2.66	0.22	-	-	-
1/7	7 to 8	7.3	-	1.65	0.14	-	-	-
1/8	8 to 9	7.4	11.67	1.39	2.10	0.00	1.68	1.68
1/9	9 to 10	7.2	9.90	3.33	0.14	0.25	4.32	2.16
1/10	10 to 11	7.2	12.84	2.35	0.18	0.33	3.84	3.04
2/1	0 to 1	7.8	-	0.12	6.78	-	-	-
2/2	1 to 2	8.0	-	0.06	0.20	-	-	-
2/3	2 to 3	8.0	-	0.51	0.53	-	-	-
2/4	3 to 4	8.0	-	0.03	0.62	-	-	-
2/5	4 to 5	7.8	6.98	0.12	5.56	0.00	0.60	1.36
2/6	5 to 6	7.8	-	0.15	6.68	-	-	-
2/7	6 to 7	7.7	6.42	0.18	4.99	0.00	0.48	0.86
2/8	7 to 8	7.8	-	0.09	0.50	-	-	-
2/9	8 to 9	7.7	7.00	0.12	5.13	0.25	0.78	1.18
3/1	0 to 1	-	-	-	-	-	-	-
3/2	1 to 2	7.6	-	0.06	0.01	-	-	-
3/3	2 to 3	7.6	-	0.06	0.01	-	-	-
3/4	3 to 4	7.6	-	0.09	0.03	-	-	-
3/5	4 to 5	7.6	-	0.04	0.20	-	-	-
3/6	5 to 6	7.6	4.57	0.04	0.18	0.00	0.64	1.06
3/7	6 to 7	7.5	5.02	0.02	0.21	-	-	-
3/8	7 to 8	7.6	4.57	0.03	0.08	0.15	0.62	0.96
3/9	8 to 9	7.6	-	0.07	0.12	-	-	-
3/10	9 to 10	7.7	11.13	1.51	0.12	0.10	2.80	2.40
3/11	10 to 11	7.8	-	2.11	0.31	-	-	-
4/4	3 to 4	7.5	-	0.26	0.33	-	-	-

BH/ UDS	Depth in meter	pH	T.O.C. %	Chlo-rides %	Sulph-ates %	Phos-phate %	Sodi-um %	Pota-ssium %
4/5	4 to 5	7.6	13.63	0.14	0.43	0.20	0.94	1.52
4/6	5 to 6	7.6	-	0.19	0.39	-	-	-
4/7	6 to 7	7.6	-	0.15	0.27	-	-	-
4/8	7 to 8	7.6	6.60	0.20	0.63	0.13	0.88	1.68
4/9	8 to 9	7.7	-	1.77	0.46	-	-	-
4/10	9 to 10	7.7	14.00	2.43	0.47	0.10	5.44	2.56
5/1	0 to 2	7.6	-	0.07	0.28	-	-	-
5/2	2 to 4	7.4	7.38	0.13	0.18	-	-	-
5/3	4 to 6	7.5	7.80	0.11	0.23	0.26	0.36	0.59
5/4	6 to 8	7.4	7.37	0.64	0.18	0.21	0.63	0.64
5/5	8 to 9	7.8	6.94	0.78	0.10	-	-	-
5/6	9 to 10	-	7.04	-	-	0.25	0.92	0.91

The main component of any soil is Silica, Alumina, Ferric Oxide and Calcium Oxide. These components were analysed seperately for the undisturbed samples of MSW drawn from bore holes and the observations are as follows :- (10mm down MSW soil)

BH/ UDS	Depth in meter	Silica %	Alumina %	Ferric Oxide %	Calcium Oxide %
1/8	8 to 9	40.70	9.58	13.89	4.26
1/9	9 to 10	30.10	10.30	15.81	5.89
1/10	10 to 11	44.74	11.01	15.49	9.81
2/5	4 to 5	32.90	7.65	14.53	12.34
2/7	6 to 7	33.50	7.03	12.93	9.81
2/9	8 to 9	32.44	10.91	14.85	4.21
3/6	5 to 6	35.84	6.47	17.57	8.41
3/8	7 to 8	37.26	8.21	11.98	8.69

BH/ UDS	Depth in meter	Silica %	Alumina %	Ferric Oxide %	Calcium Oxide %
3/10	9 to 10	40.68	11.06	14.21	10.65
4/5	4 to 5	32.68	7.57	12.45	11.50
4/8	7 to 8	33.14	8.87	15.65	13.74
4/10	9 to 10	37.80	10.35	15.81	6.73
5/3	4 to 6	32.70	6.68	10.54	7.29
5/4	6 to 8	35.00	7.95	11.65	10.93
5/6	9 to 10	44.00	10.35	15.17	5.61

In general, from these results it is noticed that average % of

Soluble Chloride in trial pits is ranging between 0.11 to 0.89 %; whereas in bore holes it is 0.02 % to 3.33 %.

Soluble Sulphate in trial pits is ranging between 0.01% to 1.34 %; whereas in bore holes it is 0.01 % to 6.78 %.

Soluble Phosphates in trial pits is ranging between 0.35% to 6.94 %; whereas in bore holes it is 0.0 % to 0.33 %

Soluble Sodium in trial pits is ranging between 0.34 % to 0.99 %; whereas in bore holes it is 0.36% to 5.44 %

Soluble Potassium in trial pits is ranging between 0.34 % to 0.41 %; whereas in bore holes it is 0.59 % to 3.04 %

Silica (SiO_2) in trial pits is ranging between 21.36 % to 33.12 %; whereas in bore holes it is 30.10 % to 44.74 %

Aluminium (Al_2O_3) in trial pits is ranging between 5.45 % to 20.44 %; whereas in bore holes it is 6.47 % to 11.06 %

Ferric Oxide (Fe_2O_3) in trial pits is ranging between 10.22 % to 14.21 %; whereas in bore holes it is 10.54 % to 17.57 %

Calcium Oxide in trial pits is ranging between 9.25 % to 23.55 %; whereas in bore holes it is 4.26 % to 13.74 %

Sr.No.	Composition	Average Values	
		T.P. 1 to 20	B.H. 1 to 5
1	pH	7.80	7.60
2	Soluble Chlorides	0.62 %	1.67 %

Sr.No.	Composition	Average Values	
		T.P. 1 to 20	B.H. 1 to 5
3	Soluble Sulphate	0.94 %	3.55 %
4	Soluble Phosphates	5.37 %	0.16 %
5	Soluble Sodium	0.90 %	3.05 %
6	Soluble Pottasium	0.65 %	1.80 %
7	SiO_2 - Silica	29.50 %	35.00 %
8	Al_2O_3 - Aluminium	10.00 %	8.75 %
9	Fe_2O_3 - Ferric Oxide	12.00 %	14.00 %
10	CaO - Calcium Oxide	13.00 %	7.50 %

Similarly, to get collective information of chemical content of the 10 mm. down size MSW soil available in dumping ground, samples drawn from T.P. No. 12, 14, 15, 19 & 20 were mixed in equal proportion and analysed for chemical composition and results are as below.

Chemical	Complex MSW
SiO_2	29.00
Al_2O_3	11.00
Fe_2O_3	13.00
CaO	11.80

From above it can be concluded that, there is no much variation in chemical composition of MSW soil at various locations in the Deonar Dumping Ground.

4.4.2 Chemical analysis of Brick making soil : -

Silica, Alumina, Ferric oxide, Calcium Oxide are the main ingredients of the soil. The chemical analysis results on Agriculture Soil & Brick Clay (mixture of agricultural, yellow soil, paddy foilage) is given below.

Composition	SiO_2	Al_2O_3	Fe_2O_3	CaO
Agricultural Soil	47.00 %	32.00 %	11.82 %	6.80 %
Brick Clay	36.00 %	20.00 %	13.45 %	5.20 %

The comparative study of chemical analysis of Agricultural Soil & Brick Clay reveals that,

- %SiO_2 is more in Agricultural Soil.
- % Al_2O_3 is more in Agricultural Soil.
- % Fe_2O_3 is slightly less in Agricultural Soil.
- % CaO is slightly more in Agricultural Soil.

4.4.3 Chemical analysis of Fly Ash :-

Chemical composition of these samples is as follows:-

Items	Tata T.P.S. Trombay Fly Ash (F1)	Reliance Energy, T.P.S. Dahanu, Fly Ash (F2)
% SiO_2	24.46	58.95
% Al_2O_3	24.78	5.71
% Fe_2O_3	15.33	6.86
% CaO	7.60	1.96

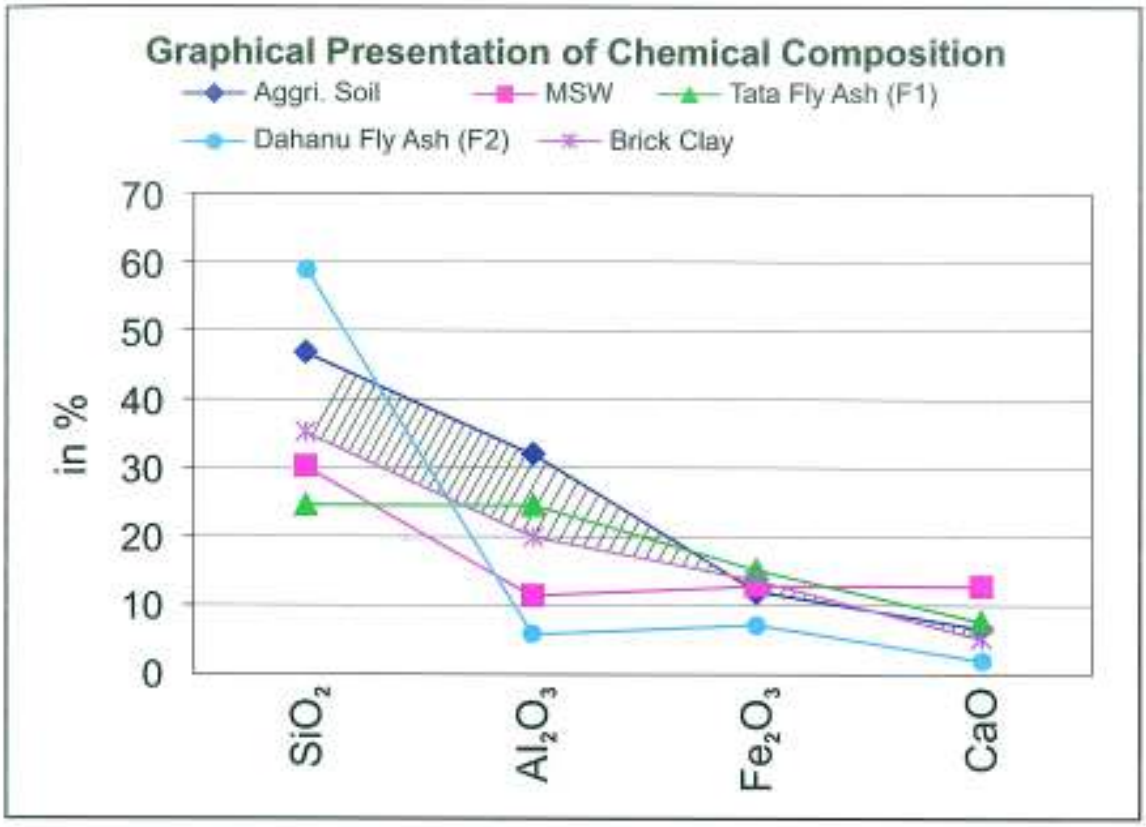
Comparative study of these fly ashes reveal that,

- % SiO_2 is more in fly ash F_2
- % Al_2O_3 is more in fly ash F_1
- % Fe_2O_3 is more in fly ash F_1
- % CaO is more in fly ash F_1

4.4.4 Comparison of Chemical composition

Table below gives the chemical composition :-

Material	T.O.C. %	Silica %	Alumina %	Ferric Oxide %	Calcium Oxide %
Agricultural Soil	5.97	46.84	32.07	11.82	6.73
Brick Clay	8.20	36.00	19.96	13.45	5.19
Fly Ash 1	0.38	24.46	24.78	15.33	7.57
Fly Ash 2	0.59	58.95	5.71	6.86	1.96
MSW	10.12	29.06	11.11	12.62	11.78



Comparison of MSW 10 mm down soil with other samples indicate that % SiO_2 is less in MSW as compared to other soil sample except fly ash F1

% Al_2O_3 is less in MSW as compared to Agricultural Soil, Brick Clay and Fly Ash F_1, but is more as compared to Fly Ash F_2 in MSW

% Fe_2O_3 in MSW is almost similar to that of Agricultural Soil, Brick Clay and Fly Ash F_1, but is more as compared to Fly Ash F_2

% CaO is more in MSW as compared to other soil samples.

From above graph it is clear that for making bricks from MSW soil it is essential that MSW soil needs to be blended so that it's chemical composition can be brought nearer to the chemical composition of brick clay and agricultural soil. The gap between the chemical composition of brick clay and agricultural soil is shown as shaded in the graph. From the experience of actual brick making it is found that even if the chemical composition of blending of MSW soil is not in the shaded portion still the bricks can be made.

4.5 Mix Design :-

After completing the engineering and chemical analysis on individual material separately a comparative study of results among the material is carried out. As regards engineering properties it is found that MSW is non-cohesive whereas brick clay and agricultural soil is a cohesive material.

Similarly, the chemical composition of soil drawn from decomposed MSW is not similar to that of brick clay / agricultural soil and has number of deficiencies. Thereby, it would be impossible to make brick exclusively by use of MSW. In fact, similar observations were made during initial three experiments. We had also observed that, the mix of about 10% of agricultural soil and soil from MSW gives good brick. That means, the deficiencies observed in properties of soil from MSW gets patched up by additions of agricultural soil. With this background, various mixes were designed at engineering and chemical laboratory separately and analysed.

4.5.1 Engineering Properties of Mixes:-

The engineering properties of number of mixes prepared using MSW soil, agricultural soil and fly ash (F1 / F2) were determined. MSW soil collected from different trial pits were mixed and used. On these mixes liquid and plastic limit and standard Proctor compaction test were carried out. The details as per mixes is as follows.

- Mix of 10mm down size MSW + Fly Ash (F1)

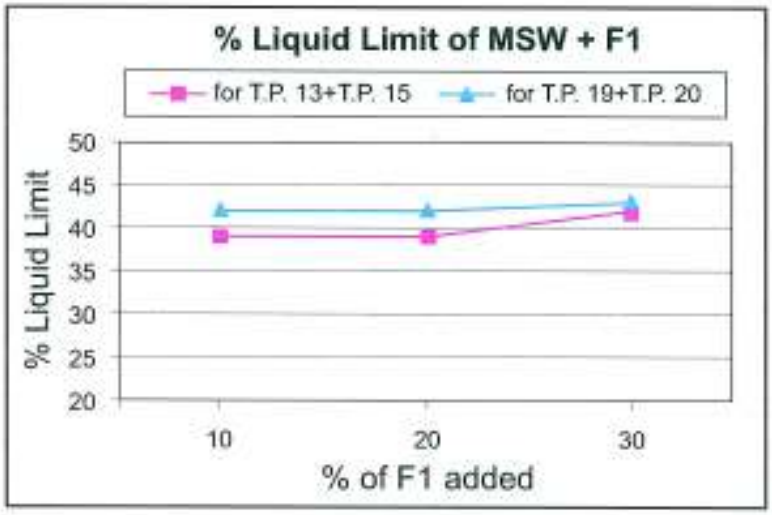
Sr.No.	Trial Pit	Sample at the depth	Mix by Weight %		Liquid Limit %	Standard Proctor Compaction Test	
			MSW	F1		o.d.d. gms/cc	o.m.c. %
1	1 + 2	0 to 4	90	10	N.P.	1.577	21.2
			80	20	N.P.	1.590	20.2
			70	30	N.P.	1.644	17.6
2	5 + 6	0 to 4	90	10	N.P.	1.533	24.1
			80	20	N.P.	1.580	21.4
			70	30	N.P.	1.610	16.7
3	9 + 10	0 to 4	90	10	40	1.345	30.0
			80	20	N.P.	1.406	26.4
			70	30	N.P.	1.437	23.4
4	13 + 15	0 to 4	90	10	39	1.431	25.3
			80	20	39	1.588	18.0
			70	30	42	1.556	20.5

Sr.No.	Trial Pit	Sample at the depth	Mix by Weight %		Liquid Limit %	Standard Proctor Compaction Test	
			MSW	F1		o.d.d. gms/cc	o.m.c. %
5	19 + 20	0 to 4	90	10	42	1.403	22.2
			80	20	43	1.463	23.2
			70	30	43	1.559	18.4

* N.P. - Non Plastic.

From above test results it is found that by the addition of fly ash F1 the plasticity of mix enhances i.e. mix becomes cohesive. Similarly liquid limit % values rise upto 43%. The o.d.d. of soil ranges between 1.345 g/cc to 1.644 g/cc which indicates that shape can be given to this mix.

Graph showing Liquid Limit of mix of MSW and Tata Fly Ash (F1)



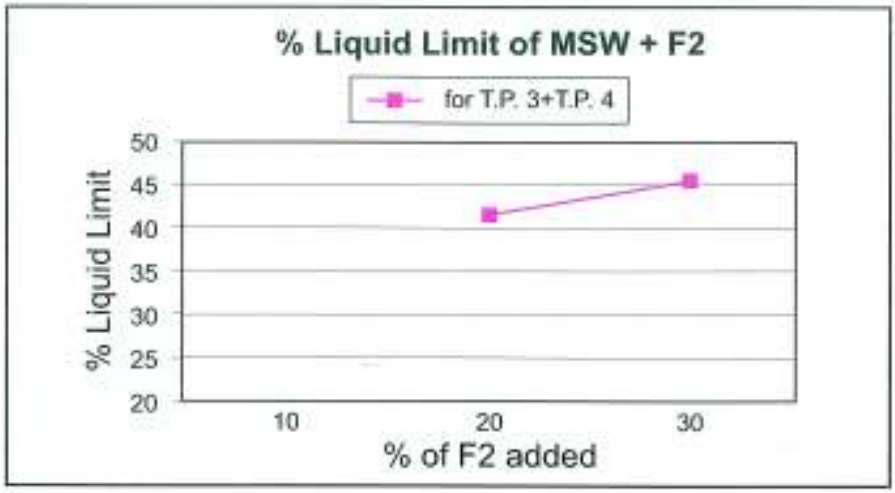
From the graph it can be seen that minimum of 10% of Tata Fly Ash needs to be added, however, further addition makes only marginal changes in the liquid limit.

➢ Mix of 10mm down size MSW + Fly ash (F_2)

Sr.No.	Trial Pit	Mix by weight (%)		Liquid Limit
		MSW	Fly Ash (F_2)	
1	3 + 4	90	10	N.P.
		80	20	41.5
		70	30	45.6

* N.P. - Non Plastic

From above test results it indicates that by addition of fly ash enhances the plasticity i.e. cohesiveness of mix and liquid limit % values rise upto 45.6%.



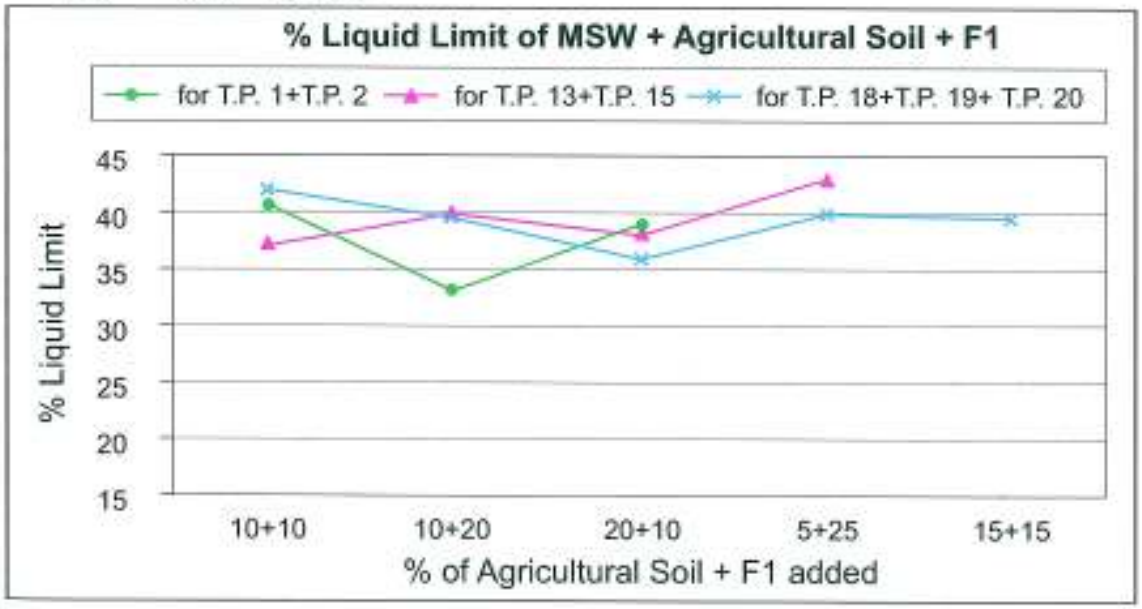
From the above graph it can be seen that more than 10% of fly ash from Dahanu Power Station needs to be added in mix to make it cohesive. By addition of 20% the mix has 41.5% liquid limit, however, further addition of fly ash makes only marginal of changes in the liquid limit.

➢ Mix of 10mm down MSW + Agricultural Soil + Fly Ash (F_1)

SR. NO.	Trail Pit	Sample at the depth in mtr.	Mix by Weight %			Liqid Limit %	Standard Proctor Compaction Test	
			MSW	Agri. Soil	F1		o.d.d. gms/cc	o.m.c. %
1	1 + 2	0 to 4	80	10	10	41.0	1.586	18.00
			70	10	20	33.5	1.614	16.80
			70	20	10	39.0	1.458	24.40
			70	5	25	N.P	1.432	20.00
			70	15	15	N.P	1.453	23.30
2	5 + 6	0 to 4	80	10	10	38.0	1.493	21.20
			70	10	20	N.P	1.572	21.50
			70	20	10	N.P	1.523	19.00
			70	5	25	N.P	1.553	18.49
			70	15	15	37.0	1.549	23.20

SR. NO.	Trail Pit	Sample at the depth in mtr.	Mix by Weight %			Liqid Limit %	Standard Proctor Compaction Test	
			MSW	Agri. Soil	F1		o.d.d. gms/cc	o.m.c. %
3	9 + 10	0 to 4	80	10	10	N.P	1.398	21.60
			70	10	20	N.P	1.385	25.80
			70	20	10	N.P	1.628	19.00
			70	5	25	N.P	1.661	16.80
			70	15	15	37.0	1.600	18.20
4	13 + 15	0 to 4	80	10	10	37.0	1.557	21.80
			70	10	20	40.0	1.586	20.60
			70	20	10	38.0	1.543	20.80
			70	5	25	43.0	1.605	19.80
			70	15	15	N.P	1.638	17.40
5	18 + 19 + 20	0 to 4	80	10	10	42.0	1.321	29.60
			70	10	20	39.5	1.404	25.40
			70	20	10	36.0	1.359	28.50
			70	5	25	40.0	1.548	18.80
			70	15	15	39.5	1.453	23.40

* N.P. - Non Plastic



From the test results it is found that the mix of MSW, agricultural soil and Fly ash (F1) has liquid limit ranging from 33.50% to 43.00%. Similarly, the o.d.d. ranges from 1.359 gm/cc to 1.638 gm/cc. It indicates that the mix has plasticity i.e. cohesiveness and it can take and maintain the shape given.

From the graph it can be seen that by addition of both agricultural soil and Tata Fly Ash in MSW the mix becomes cohesive

➢ Mix of 10mm down MSW + Agricultural Soil + Fly ash (F2)

Sr.No	Trial Pit	MSW (%)	Agri. Soil %	Fly Ash (F2) %	Liquid Limit %	o.d.d. %	o.m.c. %
1	3 + 4	80	10	10	N.P.	1.605	20.0
		70	10	20	N.P.	1.597	18.6
		70	20	10	N.P.	1.554	21.0
		70	5	25	42.8	1.561	19.4
		70	15	15	N.P.	1.547	19.2

* N.P. - Non Plastic

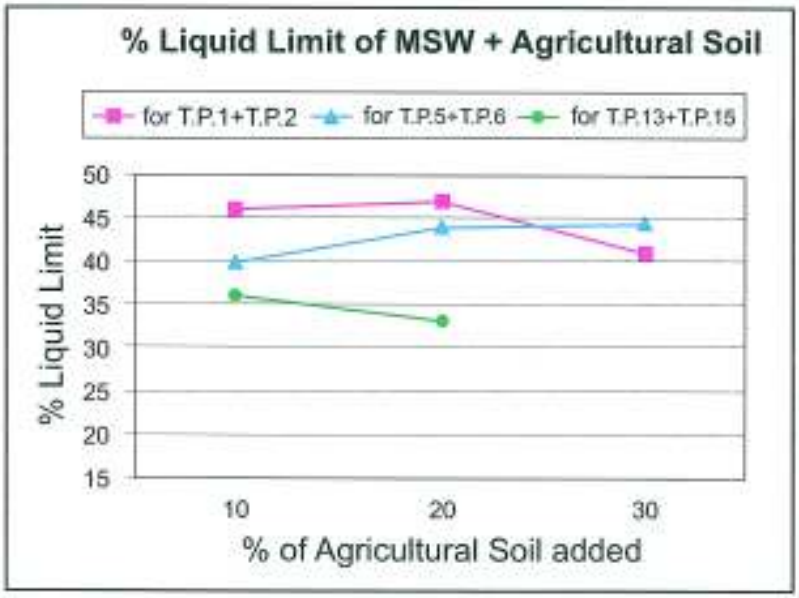
From the above test results it is found that the mix of MSW, agricultural soil and Fly ash (F2) has liquid limit ranging from N.P. to. 42.80% Similarly, the o.d.d. ranges from 1.547 gm/cc to 1.605 gm/cc. It indicates that the mix has less plasticity i.e. cohesiveness and it can take and maintain the shape given.

➢ Mix of 10mm down MSW + Agricultural Soil.

Sr.No.	Trial Pit	Sample at the depth in mtr.	Mix by Weight %		Liquid Limit %	Standard Proctor Compaction Test	
			MSW	Agri. Soil		o.d.d. gms/cc	o.m.c. %
1	1 + 2	0 to 4	90	10	46	1.574	19.0
			80	20	47	1.595	19.0
			70	30	41	1.592	20.0

Sr.No.	Trial Pit	Sample at the depth in mtr.	Mix by Weight (%)		Liquid Limit %	Standard Proctor Compaction Test	
			MSW	Agri. Soil		o.d.d. gms/cc	o.m.c. %
2	3 + 4	0 to 4	90	10	N.P	1.387	28.4
			80	20	N.P	1.388	26.7
			70	30	N.P	1.363	25.0
3	5 + 6	0 to 4	90	10	40	1.467	23.0
			80	20	44	1.463	23.4
			70	30	44.5	1.519	21.8
4	9 + 10	0 to 4	90	10	N.P	1.414	23.4
			80	20	N.P	1.414	24.2
			70	30	N.P	1.451	22.2
5	13 + 15	0 to 4	90	10	36	1.290	30.0
			80	20	33	1.372	26.0
			70	30	N.P	1.409	24.5
6	9 + 10	0 to 4	90	10	N.P	1.425	23.8
			80	20	N.P	1.458	21.8
			70	30	N.P	1.502	21.1

* N.P. - Non Plastic



From the test results it is found that the mix of MSW and agricultural soil has liquid limit ranging from 33% to 47%. Similarly, the o.d.d. ranges from 1.29 gm/cc to 1.595 gm/cc. It indicates that the mix has plasticity i.e. cohesiveness and it can take and maintain the shape given.

From the graph, it can be seen that by addition of agricultural soil the mix becomes cohesive.

➢ Mix of Agricultural Soil + Fly ash (F1)

Sr.No.	Mix by weight (%)		Liquid Limit
	Agri. Soil	Fly Ash (F1)	
1	90	10	N.P.
	80	20	N.P.
	70	30	29.2

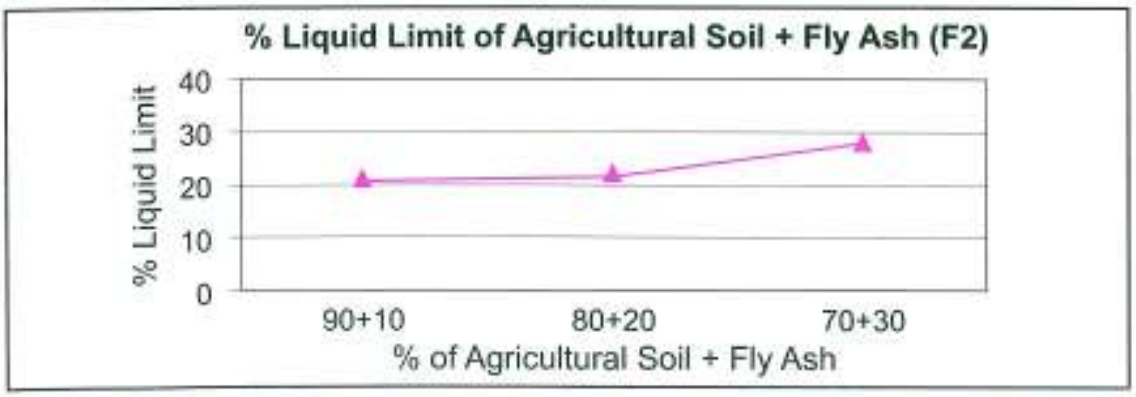
* N.P. - Non Plastic

From the above test results it is found that the mix of MSW and fly ash from Tata Thermal Power Station has liquid limit ranging from non plastic to 29.2%.

➢ Mix of Agricultural Soil + Fly Ash (F2)

Sr.No.	Mix by weight (%)		Liquid Limit
	Agri. Soil	Fly Ash (F2)	
1	90	10	21.0
	80	20	22.6
	70	30	28.1

From the above test results it is found that the mix of Agricultural Soil and Fly Ash (F2) has liquid limit ranging from 21% to 28.10%.



From above graph it can be seen that by addition of Dahanu fly ash in agricultural soil, increases the plasticity.

4.5.2 Chemical Properties of Mixes :-

While analysing the mixes for chemical properties MSW sample collected from Trial Pit number 12, 14, 15, 19, 20 is mixed in equal proportion i.e. 20% each. Along with this MSW mix sample (complex mix), the Fly Ash (F1) and Agricultural Soil is mixed in various proportion.

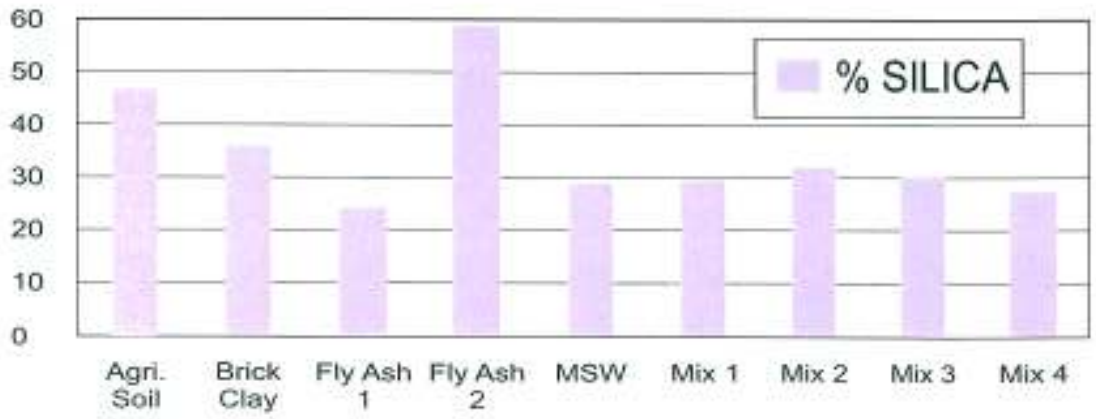
Number of mixes were analysed for chemical contents particularly of Silica (SiO_2), Alumina (Al_2O_3), Ferric Oxide (Fe_2O3) and Calcium Oxide (CaO). The combinations tried are as follows :

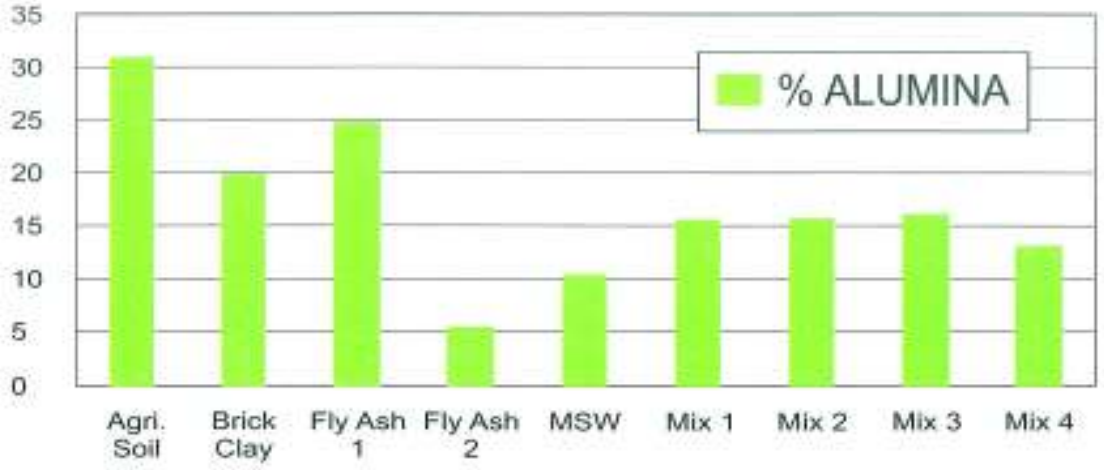
Mix	MSW	Fly Ash (F1)	Agri. Soil
I	75%	15%	10%
II	75%	10%	15%
III	70%	20%	10%
IV	80%	10%	10%

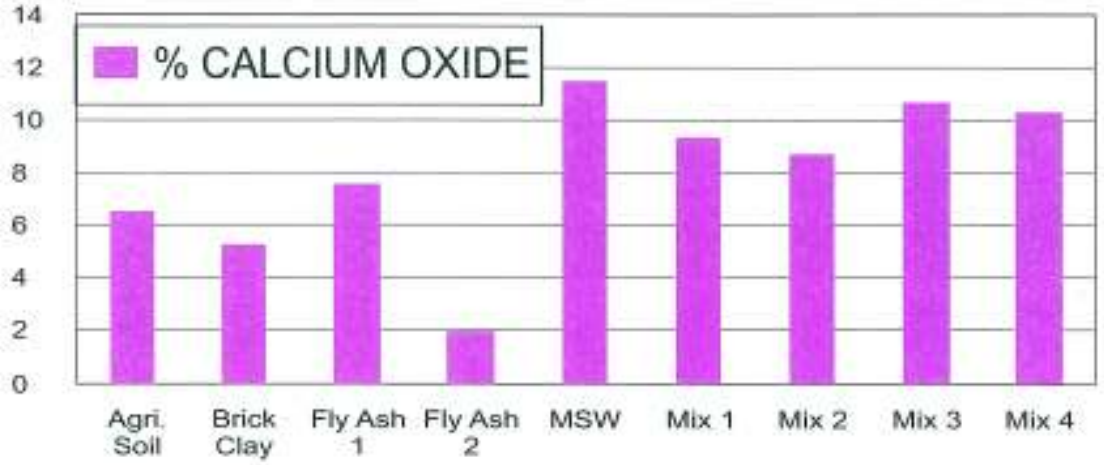
The chemical composition of above mixes is as follows :-

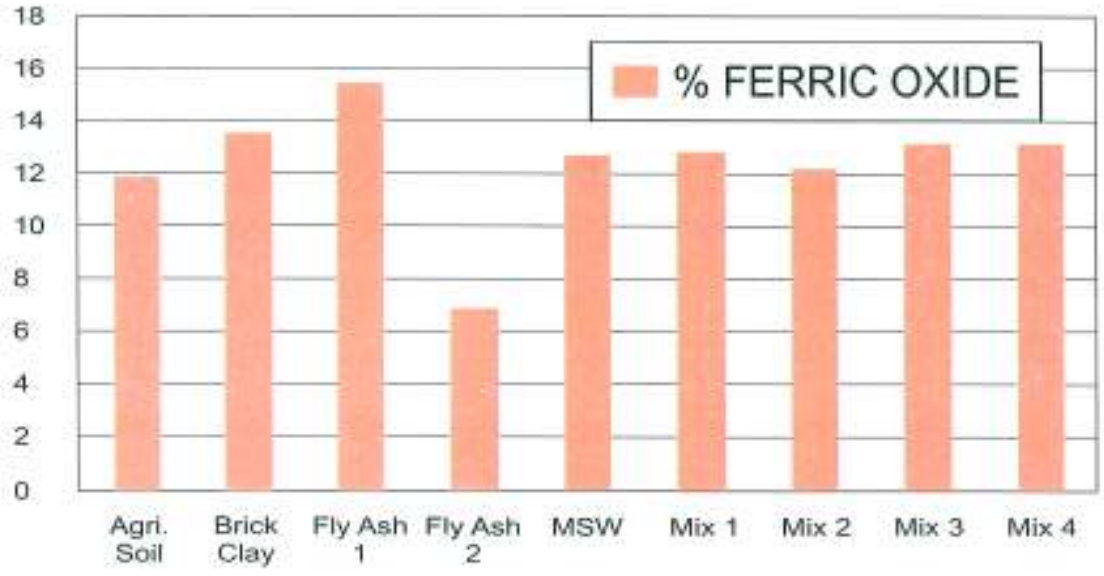
Description	Mix I	Mix II	Mix III	Mix IV
SiO_2 %	29.86	32.20	30.50	27.66
Al_2O_3 %	15.75	16.41	16.67	13.25
Fe_2O_3 %	12.77	12.14	13.09	13.09
Cao %	9.53	8.97	10.65	10.37

Graphical presentation of Silica, Alumina, Ferric Oxide and Calcium Oxide content in individual substance and mixes is as follows :-




35
30
25
20
15
10
5
0
% ALUMINA
Agri. Soil
Brick Clay
Fly Ash 1
Fly Ash 2
MSW
Mix 1
Mix 2
Mix 3
Mix 4


14
12
10
8
6
4
2
0
% CALCIUM OXIDE
Agri. Soil
Brick Clay
Fly Ash 1
Fly Ash 2
MSW
Mix 1
Mix 2
Mix 3
Mix 4


18
16
14
12
10
8
6
4
2
0
% FERRIC OXIDE
Agri. Soil
Brick Clay
Fly Ash 1
Fly Ash 2
MSW
Mix 1
Mix 2
Mix 3
Mix 4

➢ Similarly, mixes tried with the combination of MSW and agricultural soil.

Description	MSW + Agricultural Soil		
	85 +15	80 + 20	75 + 25
SiO_2	31.3	33.3	33.25
Al_2O_3	11.3	14.1	13.90
Fe_2O_3	12.0	11.8	12.24
CaO	11.6	10.5	10.40

By these combinations the silica and alumina has increased marginally, alumina has shown major increase; the ferric oxide did not show much change and the calcium oxide did not reduced as compared to the Agricultural Soil and Brick Clay. Similarly, with these mixes the alumina and silica were still lesser than agriculture soil whereas ferric oxide and calcium oxide was more.

It is noted that neither 10mm down MSW, F1, F2 alone , nor any combination is falling in the range of values for best mix.

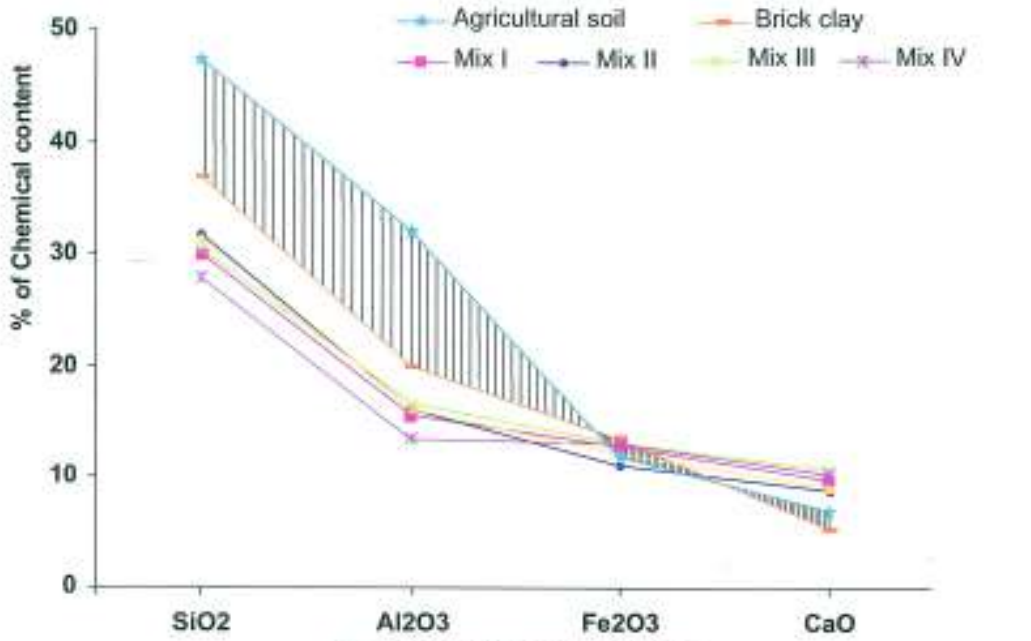
Efforts were made to analyse for its chemical content along with its proportion. Similarly in an Engineering analysis, efforts have been made to analyse the sample in comparison with agricultural soil to find suitability of mixes for making bricks.

4.5.3 Ideal Mix :-

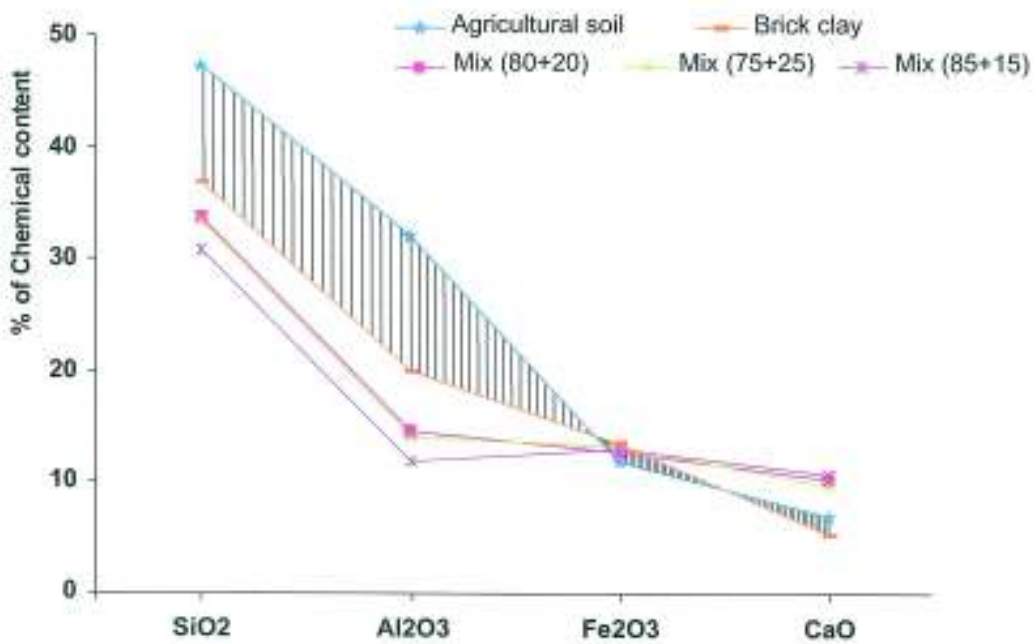
From the engineering and chemical analysis of individual material and the mixes it is clear that the brick can be made from the blending of MSW soil and either agricultural soil or fly ash. It is very essential to identify the mixes which will provide the bricks satisfying the prescribed standards. In view of this the outcome is plotted and compared with the brick clay and agricultural soil, particularly for the content of silica, alumina, ferric oxide and calcium oxide. The Ideal Mix needs to have engineering and chemical properties similar to that of brick clay and agricultural soil, however it is found that none of the mix could give the value similar to agricultural soil and brick clay. It is to mention that the bricks are generally manufactured from the soil which has chemical content between the agricultural soil and brick clay, which is shown by shaded lines in graph. During the laboratory analysis many of the mixes designed has

shown the content of silica and alumina is less, where as ferric oxide is closer and calcium oxide is more as compared to the brick clay and agricultural soil that is shown in shaded portion.

Graph showing Chemical Contents in various mixes of MSW soil with agricultural soil



Graph showing Chemical Contents in various mixes of MSW soil with fly ash F1 and agricultural soil



4.6 Microbiological Analysis (by Dr. M. G. Karmarkar G.S. Medical Collage, K.E.M. Hospital, Parel, Mumbai):-

A need for microbiological investigations was felt to know the presence of pathogens present in MSW and the risk factors of developing various infection to the labour staff handling MSW. Since such a study was not done in the past, it was decided to undertake the present study which would help in adopting appropriate measures for preventing spread of infections through MSW. The need for this study appeared to be doubled when it was learnt that 30-35% labour staff working in MSW disposal activity, die before retirement. There are several pathogenic microbes which include bacteria, viruses, fungi, parasites, etc. which can cause infections. The common modes of transmission of these microbes could be either by ingestion, inhalation, or through skin. The MSW may contain wastes from hospital, hotel industry, household and other waste from industry. Hence, there is a possibility of presence of highly infectious agents in MSW.

Facility for the detection of viruses is not available, hence, in the present study, it was decided to detect pathogenic microorganisms from bacteria, fungi and parasites.

Amongst bacterial infections typhoid, paratyphoid, cholera, diarrhea, dysentery and phylogenic infections caused by both gram negative and gram positive bacteria were the most commonly seen infections. Incidence of tuberculosis is also alarming in these people, especially in immune compromised persons. The predisposing factors for all these infections are illiteracy, poverty, and hygienic conditions dietary deficiencies, etc., apart from these we also have fungi causing superficial and systemic infections. The third important category of microorganisms includes parasites, which may get transmitted to human beings by factorial route and through skin (few human infections are identified as Zoometric infections which are transmitted by animals or insects).

4.6.1 Comparative study of Microbiological properties:-

Although MSW is expected to be a reservoir of all the pathogens, the decomposed MSW did not show presence of highly virulent pathogens, which are capable of causing serious infections.

The factors which might have affected the survival of the pathogens in decomposed MSW appear to be; status and age of solid waste, humidity, temperature, PH and availability of oxygen.

The microbiology of soil used for brick preparation and MSW used for the same did not show any significant change in microbial flora as well as the number of bacteria.

Hence, although there is some risk in handling MSW used for brick preparation, it is essential to use barrier precautions for prevention of infections. The staff engaged in brick preparation needs training for preventive measures to be used to minimize the chances of infections.

The workers who had undergone health check up at KEM Hospital were found to have Anchylostoma duodenelae (hookworm) and Strongyloides stercoralis infection.

Therefore, it is suggested that the workers need to undergo a periodic health check ups.

The proposed study was planned with following aims and activities.

Detection of pathogens (bacteria, mycobacterium, fungi and parasites) from

- Soil used for brick preparation.
- Decomposed MSW collected from Deonar Dumping ground also used for preparation of bricks.
- Comparative microbiological evaluation of soil with decomposed MSW.
- Detection of above mentioned pathogens from liechate samples.
- Screening of the staff handling MSW for brick makingfor various microbiological infections.
- Preparation of guidelines for prevention of these infections.

4.6.2 MATERIAL AND METHODS :-

For this study, 105 soil samples were collected from Deonar Dumping Ground and nearly villages where brick making is carried out (bhattis) 5 gm. of each soil sample was collected in sterile test tubes and brought to the laboratory as early as possible (immediate transportation). Soil samples were collected from the surface layers of the land where as decomposed MSW was collected from various pits dug at depths of 1, 2, 3 and 4 meters.

Processing of collected material for microbiological analysis.

Bacteriological analysis : 2 gms. Of each soil sample was suspended in 5 ccc of sterile saline and the samples were plated out on the following special media for detection of pathogens.

MEDIUM	PATHOGEN
MacConkey's Agar	Entero pathogenic bacteria
Wilson and Blair's medium	Salmonella
TCBS	Vibrio cholera
Mannitol Salt Agar	Staphylococcus aurous
Sabouraud's Slants	Fungi

With the help of nichrome wire loop, each sample was plated in duplicate on all the above-mentioned media. The plates were incubated at 37°C for 24 to 48 hours for allowing the growth of the pathogens. The results were recorded at the end of the incubation period. The organisms, which grew, were identified using biochemical tests.

Similarly, the suspended samples were cultured on Sabouraud's agar and L.J. Slants. For detection of fungi the Sabouraud's agar slants were incubated at 37°C.; and room temperature in duplicate set, for 3 to 7 days. The L.J. slants used for the detection for mycobacterium were incubated at 37°C for 3 to 4 weeks. All results were recorded.

For detection of parasites, the NaCl concentration technique was used, followed by microscopy for detection of parasites.

4.6.3 OBSERVATIONS & FINDINGS :-

- Although MSW is expected to be a reservoir of all the pathogens, the decomposed MSW did not show presence of highly virulent pathogens, which are capable of causing serious infections.
- The factors which might have affected the survival of the pathogens in decomposed MSW appear to be; status and age of solid waste, humidity, temperature, pH and availability of oxygen.
- The microbiology of soil used for brick preparation and MSW used for the same did not show any significant change in microbial flora as well as the number of bacteria.
- Hence, although there is some risk in handling MSW used for brick preparation, it is essential to use barrier precautions for prevention of infections. The staff engaged in brick preparation needs training for preventive measures to be used to minimize the chances of infections.
- The workers who had undergone health check up at KEM Hospital were found to have Anchylostoma duodenelae (hookworm) and Strongyloides stercoralis infection.

- Therefore, it is suggested that the workers need to undergo a periodic health check ups.

4.7 Workshop

With this background, we decided to hold a one-day workshop by inviting participants from various fields and to present both the outcome, so that the participants can make various suggestions, which would be helpful in completing the project. Accordingly, a one day workshop was held on 9.12.2004 at the All India Institute of Local Self Government, Andheri during which the representative from the Maharashtra State Electricity Board, Maharashtra Pollution Control Board, Municipal Corporation of Greater Mumbai, the Builders Association of India, Experts in environmental studies, representative from Strimukti Sanghatana, Brick Manufacturer were present. The workshop was inaugurated by Shri Soli Arceiwala, Founder President, Indian Environment Association, and for the conclusion, Director NEERI, Mumbai were present. During the workshop, the study carried out till date was presented. Thereafter, in the open forum, detailed discussion took place. It has been suggested that while manufacturing the brick samples, it is essential to carry out experimental analysis of air pollution. President, Builder Association of India has appreciated project and assured that the brick manufacturer from this would be duly consumed for the builder as these bricks are very environmentally friendly and cheap compared to normal bricks. The brick manufactures has agreed to be a part of this project and agreed to manufacturer bricks in the form of samples on the basis of mix designs prepared. It has been pointed out that there is a huge market for the material segregated and cannot be used for making the bricks particularly the material like plastic, metal, glass etc. The amount of such material available if segregated could have a big value and may be the manufacturing of bricks could be subsidies from this. In view of huge demand of bricks within the city limit, the participant had suggested that we should use mechanized processes so that the requirement of resources like land, laborers etc. could be reduced and also it can be possible to manufacture bricks during all season. While concluding the workshop, the Director NEERI had appreciated the work and suggested that such efforts should be encouraged should be seen that this experiments become exclusive and implemented well.

5. FIELD ACTIVITY

5.1 General :-

After completion of laboratory analysis on the samples of i) MSW drawn from Deonar Dumping Ground, ii) Agriculture soil collected from various villages in Thane Districts, iii) Fly Ash from Tata Thermal Power Station and Reliance Energy Power Station, Dahanu, mix designs were prepared. It is prima facie found that the bricks cannot be made exclusively by use of MSW soil, however, from the mix of MSW soil, agricultural soil and Fly Ash the bricks can be made.

By using mix designs number of small bricks were made in laboratory, then burnt in oven to ascertain that bricks can be made by burning.

On the completion of various analysis and preparation of mix designs in the laboratory, again efforts were reoriented towards field activity of making bricks by adopting conventional method and using mix designs prepared. While preparing each sample we came across number of issues which we debated, many a time, at site and found solutions to it. With these solutions, again preparing fresh samples with necessary modifications, again finding some issues in it which were also debated and corrective actions were taken. This process continued thereby refining the mixes methodology and the results. In project proposal, only six mix design samples were considered for brick making; however - we made 47 mix design samples for brick making. It is to mention that for this process we have made number of visits to site. Similarly Members of MMR Environment Improvement Society and number of other stake holders and interested personnel visited site. It took about six months to complete the process

While preparing these samples main thrust is given to use mixes from MSW soil, agricultural soil and fly ash in various combinations. Some samples were also prepared by using mix of MSW soil, agricultural soil, coal power, furnace oil and paddy foliage. From initial samples about 1000 numbers of bricks were made, later on it extended upto 5000 numbers. then reduced to 100 numbers and in some case only about 10 numbers of bricks were made.

5.2 Brick making for Sample no. 1 to 23 :-

The work started from 17.12.2004 with the help of thirteen workers which were brought from the place called Wada in Thane District and other nearby villages. Their arrangement for stay was made in one of the Municipal structure near Deonar Dumping Ground.

On 18.12.2004, around trial pit No.14, four pits admeasuring about 10'x8'x8' were excavated and materials kept spreaded on the side of pit for drying so that its screening becomes easier. On the same day arrangement was made for necessary tools like 6 spades, 12 ghamelas and 10mm size two sieve admeasuring 6'x4'.each. Also arranged for three cubical measuring boxes of 1'x1'x1' size each.

After air drying of excavated material, the sieving started on 19.12.2004 by use of 10 mm size sieve. The activity of screening the excavated MSW continued till 20.1.2005. The screened material was daily transported to Bulldozer garage i.e. brick making site to avoid it getting mixed with other MSW reaching the dumping ground as it is very busy dumping ground.

On 18.1.2005, five labourers were arranged to level the undulations on 60M x 30M ground in Bulldozer garage for making the brick blocks. The labourers were also engaged for cleaning and separating the bricks from brick kilns of initial experiments. The arrangements were made to bring other essential materials like one lorry load of coal, one lorry load of fly ash from Reliance Energy Thermal Power Station, Dahanu, one lorry load of sea sand (pitha), one lorry load of agricultural soil, two lorry loads of paddy foliage and two lorry loads of Fly Ash from Tata Thermal Power Station, Trombay.

On 18.1.2005, with the help of JCB machine, 9 pits admeasuring 11' x 3' x 2' deep were excavated for mixing of material and to keep it for soaking. On 22.1.2005 morning, all pits were filled with water. In the evening entire water was found percolated in the earth, therefore, sides and bottom of pits were consolidated manually to avoid further percolation. Again on 23.1.2005 morning, the pits were filled with water. Meanwhile, two sets of M.S. Plate mould having size of 9"x4"x3" depth was prepared for making brick block. Bottom plate of mould was made with the arrangement for fixing of identification number. Two sets of 0 to 9 number. made up of steel rod was also prepared for using it as identification number.

As requested, the Tata Thermal Power Station, Trombay, has provided 2 trucks of fly ash generated by them at brick manufacturing site at Deonar Dumping Ground.

The proportions of various material in the mixes were prepared on weight basis, however, to facilitate at site the proportioning of various materials it was decided to mix the material on volumetric basis by use of

1'x1'x1' size cubical boxes. To arrive at volume equivalent on the basis of their weight each material of 1'x1'x1' cubic content were weighed. The details is as follows :

Material	Air Dry Wt. kg.
MSW	21
Agricultural Soil	26
Tata Fly Ash (F1)	29
Dahanu Fly Ash (F2)	23

Sample No. 1 to 6 were made by use of 80% of MSW soil along with various proportions of agricultural soil and Tata Fly Ash. Approximately 1000 bricks were made from each sample.

In the meantime, the fly ash from the Reliance Energy Power Station, at Dahanu was also brought and sample No. 7, 8 & 9 with various proportions of MSW soil and Dahanu Fly Ash were made.

Then again to explore the possibility of refining the proportions of MSW soil, agricultural soil and fly ash, sample No.10, with 90% of MSW soil and 10% of agricultural soil was made. Similarly, in sample No.13, 95% of MSW soil and 5% agricultural soil. Sample No.14 was made exclusively by use of 100% MSW soil. Similarly, sample No.16 with 100% of Tata Fly Ash. Sample No.17 with 100% of Dahanu Fly Ash, Sample No.18 with 60% of Dahanu Fly Ash and 40% agricultural soil. Similarly, sample No.19 with 80% of Dahanu Fly ash and 20% agricultural soil.

Then we felt that instead of making about 1000 no. of brick from each sample reduce the number of bricks so that more samples could be prepared. Accordingly sample Nos. 20 to 23 have been made with the various proportions of MSW soil and agricultural soil and about 100 to 200 numbers of bricks were made from each sample.

On 23.1.2005, for sample no. 1,100 farmas of MSW, 15 farmas of brick clay and 10 farma of Tata Fly Ash mixed properly. On 24.1.2005 this mixture was put in the pit which was already filled with water. Then thoroughly mixed and kept for soaking for 24 hours.

On 25.1.2005, the mixture was taken out of the pit and kept out for twelve hours for consolidating and allowing to drain out excess water. On 26.1.2005 morning from 3.00 AM brick blocks were made by using 9"x4"x3" mould. From this mixture 827 No. of bricks were made till 9.00 AM and kept for sun drying.

The details are as below :-

Sample No.	Quantity in number of boxes of 1'x1'x1'				Date of Mixing	Date of taking out of pit.	Date of moulding of the brick blocks.	No. of Brick blocks made.
	MSW Soil	Agri. Soil	Tata Fly Ash F1	Dahanu Fly Ash F2				
1	100	15	10		24.1.05	25.1.05	26.1.05	828
2	80	24	-		25.1.05	26.1.05	27.1.05	915
3	80	-	16	-	26.1.05	27.1.05	28.1.05	785
4	80	-	44	-	27.1.05	28.1.05	29.1.05	956
5	80	4	13	-	28.1.05	29.1.05	30.1.05	851
6	100	15	17	-	29.1.05	30.1.05	31.1.05	1106
7	80	-	-	27	30.1.05	31.1.05	1.2.05	1014
8	80	-	-	75	31.1.05	1.2.05	2.2.05	1062
9	80	-	-	22	1.2.05	2.2.05	3.2.05	1036
10	80	8	-	-	2.2.05	3.2.05	4.2.05	839
11	80	4.5	3	-	3.2.05	4.2.05	5.2.05	808
12	60	9	-	-	4.2.05	5.2.05	6.2.05	757
13	40	2	-	-	5.2.05	6.2.05	7.2.05	524
14	30	-	-	-	6.2.05	7.2.05	8.2.05	270
15	60	-	8	-	7.2.05	8.2.05	9.2.05	582
16	-	-	40	-	8.2.05	9.2.05	10.2.05	486
17	-	-	-	40	9.2.05	10.2.05	11.2.05	335
18	-	20	-	40	10.2.05	11.2.05	12.2.05	532
19	-	10	-	40	11.2.05	12.2.05	13.2.05	366
20	8	8	-	-	12.2.05	13.2.05	14.2.05	132
21	9	6	-	-	12.2.05	13.2.05	14.2.05	194
22	6	9	-	-	13.2.05	14.2.05	15.2.05	199
23	6	7	-	-	13.2.05	14.2.05	15.2.05	105

Accordingly, 23 numbers of sample bricks were moulded and kept for sun drying for 7 to 10 days.

Photo 5.1 : While manual mixing.

Photo 5.2 : Mixed clay kept for soaking.

Photo 5.3 : While moulding the bricks.

Photo 5.4 : While moulding the bricks.

Photo 5.5 : While inspection of mixing.

Photo 5.6 : While sun drying and inspection.

Photo 5.7 : While sun drying of sample no. 18.

Photo 5.8 : While sun drying of sample no. 19.

Photo 5.9 : While sun drying of sample no. 20.

Photo 5.10 : While sun drying of sample no. 21.

Photo 5.11 : While sun drying of sample no. 22.

Photo 5.12 : While sun drying of sample no. 23.

Photo 5.13 : While sun drying of sample no. 23.

For burning of bricks the conventional method of brick burning bhatti or Kiln is used. In this the sun dried bricks were arranged in a certain matrix. Coal along with paddy foliage and salt is used as fuel. The bottom most layer of bricks were arranged by keeping sufficient gap to add coal. Thereafter, number of layers of bricks are arranged and again a layer with coal is laid. Similar process continued for further layers. To maintain uniform temperature and avoid heat loss, first the ground on which the kiln is proposed, is levelled, then already burnt bricks are laid. Similarly, surrounding of kiln is covered with already burnt bricks by leaving gap of about 2" to 4" from raw bricks and the joints of these bricks are sealed from outside by use of mud. The top is covered generally with brick bat and concrete debris.

In spite of above measures, the heating in this Kiln/bhatti is considerably non uniform with temperature gradient of the order of 30^{0}C on the outer side and 1300^{0}C in the inner core (as per literature).

Thereafter, by use of either kerosene or similar substance the bottom most layer which has coal is ignited. The kiln is kept burning by continuous addition of paddy foliage through the gap from top. Normally, the burning continues for 7 to 8 days then the kiln is allowed to cool for 3 to 4 days depending on surrounding temperature.

It is observed that the complete process of burning of bricks in kiln is evolved by trial and error method and on this the literature or documents is not available. Normally, the persons acquires this knowledge by way of observations and learning over longer period. It is also a special personal skill thereby such persons are normally in great demand. In our complete research work we could get the highly experienced and knowledgeable person namely Shri Kishor Vaidya who has worked for number of years on

brick making in villages of Wada Taluka, Thane District. He has brought number of experienced persons for working. In fact, he along with his colleagues were great helping hands to us in complete research work. An invaluable help and cooperation was given by them along with very meticulous efforts were made to prepare bricks from various mixes and have kept the neat records of all the activities.

In a kiln generally the brick burning process occurs in six stages (as per literature).

1. Water smoking - At this stage the evaporation of free water takes place at the temperature upto 205° C (400° F).
2. Dehydration : Dehydration occurs at temperature between 150° C to 980° C..
3. Oxidation - Occurs at temperature between 535° C to 980° C.
4. Vitrification - Occurs at temperature between 870° C to 1315° C.
5. Flashing - At the end of the burning process, the brick may be flashed to produce colour variation by injecting extra natural gas.
6. Cooling - Cooling takes place from 48 to 72 hours, depending on the type of kiln. Cooling process must be carefully controlled because too rapid cooling will cause checking and cracking in the bricks.

As stated earlier, in conventional bhatti / Kiln, temperature gradient is 30°C on outer face to 1300 °C in the inner core. Therefore, the bricks which have been properly heated ie. between temperature range of 800°C to 1300°C can be of better quality and if heating to the bricks is improper i.e. in the range of 30°C to 800°C, then it can give weak bricks. Cooling also is extremely important, therefore, considerable care shall be taken while cooling of bricks.

The details of burning of first 23 samples is as follows :

Sample No.	Date of burning	No. of layers arranged	Quantity of material used to burn the kiln in Ghamelas			Date of opening of kiln
			Coal	Paddy foliage	Ordinary salt	
1	15.2.05	12	13	4	4	23.2.05
2	16.2.05	13	15	4	3	24.2.05
3	16.2.05	17	13	4	4	24.2.05

Sample No.	Date of burning	No. of layers arranged	Quantity of material used to burn the kiln in Ghamelas			Date of opening of kiln
			Coal	Paddy foliage	Ordinary salt	
4	15.2.05	11	14	4	4	23.2.05
5	17.2.05	10	14	3	-	25.2.05
6	17.2.05	12	13	3	-	25.2.05
7	15.2.05	11	15	3	3	23.2.05
8	15.2.05	17	18	4	-	23.2.05
9	18.2.05	11	16	3	-	26.2.05
10	18.2.05	9	10	3	-	26.2.05
11	19.2.05	12	14	3	-	27.2.05
12	19.2.05	11	13	3	4	27.2.05
13	19.2.05	11	13	4	-	27.2.05
14	18.2.05	10	4	1	-	26.2.05
15	18.2.05	11	10	2	-	26.2.05
16	19.2.05	12	8	2	-	27.2.05
17	25.2.05	9	10	2	-	5.3.05
18	26.2.05	10	10	2	-	6.3.05
19	19.2.05	8	5	1	-	27.2.05
20	21.2.05	7	2	1	-	1.3.05
21	20.2.05	7	3	1	-	28.2.05
22	22.2.05	7	3	1	-	2.3.05
23	23.2.05	5	2	1	-	3.3.05

Photo 5.14 : Arranging 1st layer of kiln for sample no. 1.

Photo 5.15 : Arranging 2nd layer of kiln for sample no. 1.

Photo 5.16 : Arranging 2nd layer of kiln for sample no. 1.

Photo 5.17 : Completing 2nd layer of kiln for sample no. 1.

Photo 5.18 : Completing 2nd layer of kiln for sample no. 1.

Photo 5.19 : Arranging 3rd layer of kiln for sample no. 1.

Photo 5.20 : Completing 3rd layer of kiln for sample no. 1.

Photo 5.21 : Completing 4th layer of kiln for sample no. 1.

Photo 5.22 : Completing 4th layer of kiln for sample no. 1.

Photo 5.23 : Arranging 5th layer of kiln for sample no. 1.

Photo 5.24 : Arranging 5th layer of kiln for sample no. 1.

Photo 5.25 : Adding coal at 5th layer of kiln for sample no. 1.

Photo 5.26 : Adding coal at 5th layer of kiln for sample no. 1.

Photo 5.27 : Adding paddy foilage at 5th layer of kiln for sample no. 1.

Photo 5.28 : Adding salt at 5th layer of kiln for sample no. 1.

Photo 5.29 : Adding salt at 5th layer of kiln for sample no. 1.

Photo 5.30 : Completing 5th layer of kiln for sample no. 1.

Photo 5.31 : Arranging 6th layer of kiln of sample no. 1.

Photo 5.32 : Completing 6th layer of kiln for sample no. 1.

Photo 5.33 : Arranging 7th layer of kiln for sample no. 1

Photo 5.34 : Completing 7th layer of kiln for sample no. 1

Photo 5.35 : Completing 8th layer of kiln for sample no. 1

Photo 5.36 : Completing 8th layer of kiln for sample no. 1

Photo 5.37 : Burning of kiln.

Photo 5.38 : Burning of kiln.

Photo 5.39 : Burning of kiln.

Photo 5.40 : Burning of kiln.

Photo 5.41 : Burning of kiln.

Photo 5.42 : Burning of kiln.

Photo 5.43 : Burning of kiln.

Photo 5.44 : While arranging kiln.

Photo 5.45 : While opening of kiln of sample no. 2.

Photo 5.46 : The burnt bricks of sample no. 2.

Photo 5.47 : Burnt bricks of sample no. 2.

Photo 5.48 : Burnt brick of sample no. 4.

Photo 5.49 : Burnt bricks of sample no. 8.

Photo 5.50 : While arranging kiln of sample no. 11.

Photo 5.51 : Burnt bricks of sample no. 11.

Photo 5.52 : While arranging kiln for sample no. 13.

Photo 5.53 : Burnt bricks of sample no. 13.

After opening of kiln the samples of burnt bricks were sent to Structural Engineering Laboratory, VJTI and Mumbai Municipal Corporation Laboratory for testing as per IS 1077. The test results are as follows :

Sr. No.	Sample No.	Size of brick in cm.	Crushing load in mt.	Compressive strength, kg/cm^2	% water absorption
1.	1(1)	21.5 x 9.5 x 7	02.7	13.20	15.62
2.	1(2)	21.5 x 9.5 x 7	03.5	17.10	30.90
3.	2(1)	22 x 9.5 x 7	03.6	17.20	52.09
4.	2(2)	22 x 9.5 x 7	10.1	48.30	42.50
5.	3(1)	23 x 10 x 7	14.6	63.48	22.04
6.	3(2)	23 x 10 x 7	10.0	43.50	12.50
7.	4(1)	22.5 x 10 x 7	02.8	12.40	40.90
8.	4(2)	22.5 x 10 x 7	04.7	20.90	27.30
9.	5(1)	22 x 10 x 7	02.4	10.90	40.40
10.	5(2)	22 x 10 x 7	05.2	26.60	40.90
11.	6(1)	21.5 x 10 x 7.5	12.5	58.10	29.00
12.	6(2)	21.5 x 10 x 7.5	12.9	60.00	29.50
13.	7(1)	21.5 x 10 x 7	04.9	22.80	38.30
14.	7(2)	21.5 x 10 x 7	03.6	16.74	32.76
15.	8(1)	21 x 10 x 7	13.2	62.90	12.40
16.	8(2)	21 x 10 x 7	14.8	70.50	17.50
17.	9(1)	22 x 10 x 7	06.7	30.50	38.78

Sr. No.	Sample No.	Size of brick in cm.	Crushing load in mt.	Compressive strength, kg/cm^2	% water absorption
18.	9(2)	22 x 10 x 7	07.9	35.90	33.98
19.	9(3)	23 x 10 x 7.7	03.2	13.91	-
20.	10(1)	22 x 9.5 x 7	03.6	17.20	20.15
21.	10(2)	22 x 9.5 x 7	05.7	27.30	11.70
22.	10(3)	23.8 x 10 x7	00.8	03.36	-
23.	11(1)	22 x 10 x 7	02.4	10.90	41.00
24.	11(2)	22 x 10 x 7	08.1	36.80	33.86
25.	11(3)	22 x 10 x 7.5	00.8	03.64	-
26.	12(1)	21.5 x 10 x 7	03.8	17.60	30.90
27.	12(2)	21.5 x 10 x 7	02.8	13.00	36.70
28.	15(1)	22.5 x 10 x 7	08.3	36.90	37.00
29.	15(2)	22.5 x 10 x 7	11.2	49.80	28.90
30.	16(1)	21.5 x 10 x 7	08.6	40.00	26.29
31.	16(2)	21.5 x 10 x 7	06.6	30.70	32.23
32.	17(1)	22.5 x 10 x 7	04.7	20.90	45.90
33.	17(2)	22.5 x 10 x 7	05.9	26.20	36.57
34.	17(3)	22 x 10.2 x 7.7	02.5	11.14	-
35.	18(1)	20.5 x 10 x 7	05.8	28.30	27.80
36.	18(2)	20.5 x 10 x 7	06.9	33.65	37.90
37.	18(3)	23 x 10 x 7.5	02.0	08.70	-
38.	19(1)	22.5 x 10 x 7	02.7	12.60	41.10
39.	19(2)	22.5 x 10 x 7	05.7	25.30	45.80
40.	19(3)	23.7 x 10.5 x 7.5	00.7	02.81	-
41.	20(1)	22 x 10 x 7	12.8	58.20	31.55
42.	20(2)	22 x 10 x 7	13.2	60.00	36.67
43.	20(3)	21 x 9.8 x 7.0	02.8	13.61	-
44.	21(1)	22 x 10 x 7	05.7	25.90	20.05
45.	21(2)	22 x 10 x 7	02.9	13.20	22.06
46.	21(3)	21 x 10 x 7.5	02.5	11.90	-
47.	22(1)	22 x 10 x 7	02.2	10.00	19.30

Sr. No.	Sample No.	Size of brick in cm.	Crushing load in mt.	Compressive strength, kg/cm^2	% water absorption
48.	22(2)	22 x 10 x 7	01.9	08.60	22.95
49.	23(1)	22.5 x 10 x 7.5	02.5	11.10	47.06
50.	23(2)	22.5 x 10 x 7.5	03.4	15.10	48.80

5.3 Brick making for sample No. 24 to 28

Small quantity of bricks were made in sample No. 24 to 28. In these samples some quantity of Gypsum and Yellow Soil was added and observations are made. It is seen that the breakage is less and has become good quality brick. The details are as follows:

Date	Sam-ple No.	Quantity in number of boxes of 1'x1'x1'					Gypsum in gms.	No. of Bricks			
		MSW Earth	Agri. Soil	Tata Ash F1	Da-hanu Ash F2	Yell-ow Soil		Made	Bro-ken	Good burnt	Good burnt sent for testing
18.3.05	24	1	1/2	-	-	-	680	15	2	13	-
19.3.05	25	1	-	1/4	-	-	681	16	16	-	-
20.3.05	26	1	-	-	1/2	-	681	12	2	10	2
21.3.05	27	1	-	-	-	1/2	-	16	-	16	2
22.3.05	28	1	-	-	-	1/6	-	16	2	14	2

Photo 5.54 : Inspecting the burnt bricks of sample no. 24.

Photo 5.55 : Inspecting the burnt bricks of sample.

Photo 5.56 : Inspecting the burnt bricks of samples.

Photo 5.57 : Inspecting the burnt bricks of samples.

5.4 Brick Making for Sample No. 31 to 41:-

From the test results of above samples it is found that the bricks made from Fly Ash from Dahanu are good in strength, therefore, the next experiments were conducted by using Fly Ash from Dahanu. It has felt that while mixing in pits the water percolates down thereby not getting proper mix, hence, we have made one tin box admeasuring 6'x4'x2' height to accommodate material of about 10 numbers. of 1'x1'x1' size boxes. About 100 to 130 numbers. of bricks were made from each sample.

Sample No.	Date of making bricks	Mix in number of 1'x1'x1" boxes			No. of Katcha bricks	Broken Bricks	Good burnt bricks
		MSW soil	Dahanu Ash	Agri. Soil			
31	9.4.05	7	3	-	121	32	89
32	10.4.05	6	4	-	111	22	89
33	8.4.05	5	5	-	110	33	87
34	11.4.05	4	6	-	105	25	81
35	12.4.05	3	7	-	122	7	115
36	13.4.05	7	1	2	126	50	76
37	14.4.05	5	2	2	120	32	88
38	15.4.05	5	3	2	108	35	73
39	16.4.05	7	2	1	113	72	43
40	17.4.05	5	4	1	102	35	67
41	18.4.05	6	3	1	113	66	47

Photo 5.58 : Fly ash from Dahanu Power Station.

5.4 Brick Making for Sample No. 31 to 41:-

From the test results of above samples it is found that the bricks made from Fly Ash from Dahanu are good in strength, therefore, the next experiments were conducted by using Fly Ash from Dahanu. It has felt that while mixing in pits the water percolates down thereby not getting proper mix, hence, we have made one tin box admeasuring 6'x4'x2' height to accommodate material of about 10 numbers. of 1'x1'x1' size boxes. About 100 to 130 numbers. of bricks were made from each sample.

Sample No.	Date of making bricks	Mix in number of 1'x1'x1" boxes			No. of Katcha bricks	Broken Bricks	Good burnt bricks
		MSW soil	Dahanu Ash	Agri. Soil			
31	9.4.05	7	3	-	121	32	89
32	10.4.05	6	4	-	111	22	89
33	8.4.05	5	5	-	110	33	87
34	11.4.05	4	6	-	105	25	81
35	12.4.05	3	7	-	122	7	115
36	13.4.05	7	1	2	126	50	76
37	14.4.05	5	2	2	120	32	88
38	15.4.05	5	3	2	108	35	73
39	16.4.05	7	2	1	113	72	43
40	17.4.05	5	4	1	102	35	67
41	18.4.05	6	3	1	113	66	47

Photo 5.58 : Fly ash from Dahanu Power Station.

Photo 5.59 : Special container used for mixing.

Photo 5.60 : Preparing dry mix.

Photo 5.61 : Preparing dry mix.

Photo 5.62 : Preparing dry mix.

Photo 5.63 : Preparing dry mix.

Photo 5.64 : Adding water in dry mix.

Photo 5.65 : Adding water in dry mix.

Photo 5.66 : Thorough mixing.

Photo 5.67 : Thorough mixing.

Photo 5.68 : Wet mix.

Photo 5.69 : Inspection of wet mix.

Photo 5.70 : Inspection of wet mix.

Photo 5.71 : Inspection of wet mix.

Photo 5.72 : Numbering burnt bricks.

Photo 5.73 : Control cooling by keeping burnt bricks in water

Photo 5.74 : Control cooling by keeping burnt bricks in water

Photo 5.75 : Inspection of site.

Photo 5.76 : Agricultural soil.

Photo 5.77 : Fly ash.

Photo 5.78 : Use of mechanical mixer.

Photo 5.79 : Use of mechanical mixer.

Photo 5.80 : Mixing by mechanical mixer.

Photo 5.81 : Mixing by mechanical mixer.

Photo 5.82 : Mix before mixing

Photo 5.83 : Adding water to mix.

Photo 5.84 : Loading dry mix.

Photo 5.85 : Unloading wet mix.

Photo 5.86 : Wet mix.

Photo 5.87 : Wet mix.

Photo 5.88 : Adding paddy foilage to mix.

Photo 5.89 : Use of furnace oil in some samples.

Photo 5.90 : Moulding of bricks.

Photo 5.91 : Sun drying of bricks.

Photo 5.92 : Sun drying of bricks.

Photo 5.93 : Sun drying of bricks.

Photo 5.94 : Sun drying of bricks.

Photo 5.95 : Arranging 1st layer of kiln of sample no. 53.

Photo 5.96 : Arranging kiln of sample no. 52.

Photo 5.97 : Arranging kiln of sample no. 52.

Photo 5.98 : Burning of kiln

Photo 5.99 : Burning of kiln

Photo 5.100 : Burning of kiln

Photo 5.101 : Burnt bricks of sample no. 51.

The bricks were arranged in proper layers to make 11 brick kilns from 16.4.2005 to 25.4.2005 and burnt. These kilns were opened between 25.4.2005 and 3.5.2005.

After opening of kiln the samples of burnt bricks were sent to Structural Engineering Laboratory, VJTI and Mumbai Municipal Corporation Laboratory for testing as per IS 1077. The test results are as follows :

Sr. No.	Sample No.	Size of brick in cm.	Crushing load in mt.	Compressive strength, kg/cm^2	% water absorption
1	31(1)	22.8 x 10.1 x 7.2	4.8	21.00	20.26
2	31(2)	22.8 x 10.1 x 7.2	3.2	14.00	24.99
3	31(3)	23.5 x 10.0 x 7.5	3.6	15.32	-
4	31(4)	23.5 x 10.0 x 7.5	4.4	18.70	-
5	32(1)	22.7 x 10.0 x 7.1	5.1	22.50	26.13
6	32(2)	22.7 x 10.0 x 7.1	6.2	27.30	21.19
7	32(3)	23.6 x 10.0 x 7.6	2.8	11.86	-
8	32(4)	23.6 x 10.0 x 7.6	6.9	29.24	-
9	33(1)	22.6 x 10.0 x 7.1	3.6	15.90	24.02
10	33(2)	22.6 x 10.0 x 7.1	3.8	16.80	23.87
11	33(3)	23.5 x 10.0 x 7.6	3.6	15.32	-
12	33(4)	23.5 x 10.0 x 7.6	1.8	07.66	-
13	34(1)	22.7 x 10.0 x 7.0	7.2	31.70	22.73

Sr. No.	Sample No.	Size of brick in cm.	Crushing load in mt.	Compressive strength, kg/cm^2	% water absorption
14	34(2)	22.7 x 10.0 x 7.0	2.4	10.50	16.37
15	34(3)	24.1 x 10.0 x 7.8	10.9	45.23	-
16	35(1)	22.0 x 10.0 x 7.0	6.8	30.90	27.39
17	35(2)	22.0 x 10.0 x 7.0	5.2	23.60	19.76
18	35(3)	23.6 x 10.0 x 7.6	5.8	24.58	-
19	35(4)	23.6 x 10.0 x 7.6	6.8	28.81	-
20	36(1)	22.0 x 10.7 x 7.0	3.4	15.50	29.80
21	36(2)	22.0 x 10.7 x 7.0	3.1	14.00	28.48
22	37(1)	22.1 x 10.7 x 7.0	3.2	14.50	26.94
23	37(2)	22.1 x 10.7 x 7.0	2.8	12.70	26.70
24	38(1)	22.1 x 10.7 x 7.0	4.5	20.50	25.70
25	38(2)	22.1 x 10.7 x 7.0	4.6	20.90	25.11
26	39(1)	22.1 x 10.7 x 7.0	2.1	09.50	28.20
27	39(2)	22.1 x 10.7 x 7.0	2.0	09.00	29.40
28	40(1)	22.0 x 10.7 x 7.0	4.0	18.20	29.52
29	40(2)	22.0 x 10.7 x 7.0	3.6	16.40	29.00
30	41(1)	22.0 x 10.0 x 7.0	3.8	17.20	29.40
31	41(2)	22.0 x 10.0 x 7.0	2.9	13.20	30.00

5.5 Brick making from Sample No. 51 to 58:-

Thereafter, for proper mixing and to make the homogenous mix, mechanical mixer was brought at site. Also to make pit water tight a plastic sheet is covered around the side and bottom. The MSW soil and Fly Ash from Dahanu was mixed in different proportion. As shown in the following table bricks were made. In some of the mixes coal powder, furnace oil, paddy foliage is also mixed.

As mentioned earlier number of interested personal visited site and gave number of suggestion similarly in one of the meeting commissioner MMRDA has suggested that the outcome of this research is of Technical nature and may not be understood by all hence asked to construct a structure by using these bricks, thereby let people see and realize the usefulness of research work. Accordingly a structure of 8 feet x 10 feet size

which has plinth height of about 2 " constructed near brick making site. The height of structure is 12 feet with sloping roof. Side walls and plinth is made up by using bricks made during these experiments. One door and two windows have been fixed. Flooring is made up of concretes. To observe the effect of environment we intentionally did not plaster the walls from outside. The structure is very well standing till date. It has also survived complete submergence during 26th July, 05 deluge. The structure is absolutely similar to the structure made up by use of normal bricks and it is fit for human habitation.

Sample No. 1	Date of moulding bricks 2	Quantity in number of boxes of 1'x1'x1' size			Quantity in Litres		
		MSW 3	Fly Ash (F2) 4	Agri. Soil 5	Coal Powder 6	Furnace Oil 7	Tus 8
51	4 to 9.5.05	280	280	-	-	-	-
52	9 to 12.5.05	240	160	-	-	-	-
53	13 to 15.5.05	214	104		-	-	-
54	17 to 24.5.05	214		104	-	-	-
55	25.5.05	5	5	-	10	3	5
56	25.5.05	6	4	-	10	3	5
57	26.5.05	7	3	-	10	3	5
58	26.5.05	7	-	3	10	3	5

Sample No.	Date of moulding bricks 9	No. of brick 10		
		Made	Broken	Good burnt
51	4.5.05 to 9.5.05	5816	2991	2825
52	9.5.05 to 12.5.05	4299	1709	2506
53	13.5.05 to 15.5.05	3460	1358	2102
54	17.5.05 to 24.5.05	3699	2446	1253
55	25.5.05	107	39	68
56	25.5.05	106	26	80
57	26.5.05	107	22	85
58	26.5.05	119	11	108

The above bricks were arranged in layers to make brick kilns and burnt it from 20.5.05 to 7.6.05. From each of above samples 12 and 10 bricks sample were sent to Municipal Laboratory at Worli and V.J.T.I. respectively for testing. And the results given are as follows :

Sr. No.	Sample No.	Size of brick in cm.	Compressive strength, kg/cm^2	% water absorption
1.	51	22 x 10 x 7	46.83	36.63
2.	52	22 x 10 x 7	26.25	38.21
3.	53	22 x 10 x 7	2.80	31.87
4.	54	22 x 10 x 7	10.20	25.44
5.	55	22 x 10 x 7	17.60	35.37
6.	56	22 x 10 x 7	11.37	33.05
7.	57	22 x 10 x 7	23.80	34.81
8.	58	22 x 10 x 7	30.20	27.67

5.6 Ambient air quality monitoring details :-

During one of the visit of members of MMR Environment Improvement Society to the brick making site at Deonar Dumping Ground, the Chief Planing Division has insisted, for carrying out Ambient Air Analysis and other laboratory analysis. Further she stated that the Thane Municipal Corporation has well develop laboratory and they can do the needful. Accordingly, we contacted in charge of Environment laboratory Thane Municipal Corporation, from whom we have got the burnt brick tested for calcium content. Similarly, during the burning of bricks of various samples Ambient air monitoring was carried out from Date 18.05.2005 to 09.06.2006 on the 24 X 7 basis. During this process samples were collected four times in a day. i.e. at 8.00 hrs; 12.00 hrs; 16.00 hrs; 20.00 hrs. The collected samples were transported to the Environment laboratory of Thane Municipal Corporation. It is to mention that, the number of brick kiln's were simultaneously burning during this period. The nearest kiln was about 15 feet away from the "Ambient Air Monitoring Unit". Similarly the height of unit was kept such that, the unit is just above the height of the kiln.

It is also to mention that, for all these 20 days Mr. Rohan B.E (Mech.) who is enthusiastically and actively participated and collected the samples. From the above it could be clear that, Mr. Rohan was almost stationed at brick kiln site at Deonar Dumping Ground. The work has been

carried out in extremely meticulous way. Mr. Rohan was also transporting the samples to the Environment laboratory of Thane Municipal Corporation. The details are as follows :

Sr. no.	From		To		Air Cantents				Filter Paper	Dust Present	
	Date	Time	Date	Time	SO_2	NO_X	NH_3	H_2S		R.S.P.M	N.R.S.P.M
1	18/05/05	8:30	18/05/05	12:00	3	4	11	18			
2	19/05/05	15:00	19/05/05	19:00	5	4	35	12			
3	19/05/05	20:00	20/05/05	8:00	6	5	24	10			
4	20/05/05	8:30	20/05/05	12:30	8	8	137	13	1	332.98	1379
5	20/05/05	13:00	20/05/05	17:00	12	11	83	24			
6	20/05/05	17:15	20/05/05	21:15	9	6	131	17			
7	20/05/05	21:30	21/05/05	9:30	7	13	55	16			
8	21/05/05	10:00	21/05/05	14:00	11	4	46	15			
9	21/05/05	14:15	21/05/05	18:15	5	12	19	20			
10	21/05/05	19:00	21/05/05	20:00	7	16	27	15	2	352.34	2193
11	21/05/05	20:00	22/05/05	8:00	18	18	22	14			
12	22/05/05	16:00	22/05/05	19:30	5	46	34	12			
13	22/05/05	20:00	23/05/05	8:00	18	23	40	14			
14	23/05/05	8:30	23/05/05	11:30	7	24	40	24	3	580.83	1403
15	23/05/05	12:00	23/05/05	15:30	19	10	54	16			
16	23/05/05	16:00	23/05/05	19:30	11	23	51	15			
17	23/05/05	20:00	24/05/05	8:00	16	25	59	8			
18	24/05/05	8:30	24/05/05	11:30	12	13	50	16			
19	24/05/05	12:00	24/05/05	15:30	9	21	71	31			
20	24/05/05	16:00	24/05/05	19:30	12	30	41	28	4	519.84	1738
21	24/05/05	20:00	25/05/05	8:00	10	27	43	25			
22	25/05/05	8:30	25/05/05	11:30	8	22	33	21	5	404.31	4057
23	25/05/05	12:00	25/05/05	15:30	7	18	21	24			

Sr. no.	From		To		Air Cantents				Filter Paper	Dust Present	
	Date	Time	Date	Time	SO_2	NO_x	NH_3	H_2S		R.S.P.M	N.R.S.P.M
24	25/05/05	16:00	25/05/05	19:30	10	61	19	23	5	404.31	4057
25	25/05/05	20:00	26/05/05	8:00	12	25	13	20			
26	26/05/05	8:30	26/05/05	11:30	11	3	24	20			
27	26/05/05	12:00	26/05/05	15:30	10	32	40	13			
28	26/05/05	16:00	26/05/05	19:30	7	29	38	14	6	491.13	1165
29	26/05/05	20:00	27/05/05	8:00	7	42	34	16			
30	27/05/05	8:30	27/05/05	11:30	5	27	47	19			
31	27/05/05	12:00	27/05/05	15:30	7	33	43	17			
32	27/05/05	16:00	27/05/05	19:30	10	36	26	17	7	362.72	5705
33	27/05/05	20:00	28/05/05	8:00	9	21	27	15			
34	28/05/05	8:30	28/05/05	11:30	12	17	47	20			
35	28/05/05	12:00	28/05/05	15:30	10	22	23	24			
36	28/05/05	16:00	28/05/05	19:30	9	20	25	17	8	405	3373
37	28/05/05	20:00	29/05/05	8:00	14	19	25	23			
38	29/05/05	8:30	29/05/05	11:30	11	24	28	18			
39	29/05/05	12:00	29/05/05	15:30	12	-	23	19			
40	29/05/05	16:00	29/05/05	19:30	9	-	26	18	9	230.15	1841
41	29/05/05	20:00	30/05/05	8:00	8	-	27	14			
42	30/05/05	8:30	30/05/05	11:30	-	-	11	3			
43	30/05/05	12:00	30/05/05	15:30	-	-	19	6			
44	30/05/05	16:00	30/05/05	19:30	3	68	13	18	10	481	1752
45	30/05/05	20:00	31/05/05	8:00	6	81	21	13			
46	31/05/05	8:30	31/05/05	11:30	5	81	54	11			
47	31/05/05	12:00	31/05/05	15:30	4	45	30	5			
48	31/05/05	16:00	31/05/05	19:30	2	48	16	13	11	393	1678
49	31/05/05	20:00	01/06/05	8:00	2	45	20	7			

Sr. no.	From		To		Air Cantents				Filter Paper	Dust Present	
	Date	Time	Date	Time	SO_2	NO_x	NH_3	H_2S		R.S. P.M	N.R.S. P.M
50	01/06/05	8:30	01/06/05	11:30	9	18	42	20			
51	01/06/05	12:00	01/06/05	15:30	4	35	25	30			
52	01/06/05	16:00	01/06/05	19:30	7	17	13	29	12	431	1978
53	01/06/05	20:00	02/06/05	8:00	8	18	11	32			
54	02/06/05	8:30	02/06/05	11:30	10	13	17	24			
55	02/06/05	12:00	02/06/05	15:30	7	17	12	11			
56	02/06/05	16:00	02/06/05	19:30	11	17	19	16	13	421	1262
57	02/06/05	20:00	03/06/05	8:00	7	19	14	20			
58	03/06/05	8:30	03/06/05	11:30	7	16	13	15			
59	03/06/05	12:00	03/06/05	15:30	8	17	12	8	14	502	713
60	03/06/05	20:00	04/06/05	8:00	9	15	8	9			
61	04/06/05	8:30	04/06/05	11:30	7	21	15	14			
62	04/06/05	12:00	04/06/05	15:30	7	19	10	22			
63	04/06/05	16:00	04/06/05	19:30	11	11	8	16	15	332	649
64	04/06/05	20:00	05/06/05	8:00	9	19	7	21			
65	05/06/05	8:30	05/06/05	11:30	8	17	10	16			
66	05/06/05	12:00	05/06/05	15:30	7	21	11	21			
67	05/06/05	16:00	05/06/05	19:30	5	21	14	16	16	237	437
68	05/06/05	20:00	06/06/05	8:00	7	18	13	20			
69	06/06/05	8:30	06/06/05	11:30	9	17	13	13			
70	06/06/05	16:00	06/06/05	19:30	9	20	9	11	17	318	341
71	06/06/05	20:00	07/06/05	8:00	6	15	6	9			
72	07/06/05	8:30	07/06/05	11:30	9	13	13	14			
73	07/06/05	12:00	07/06/05	15:30	9	13	12	16	18	209	276
74	07/06/05	20:00	08/06/05	8:00	7	11	13	11			
75	08/06/05	8:30	08/06/05	11:30	7	10	6	10	19	215	314

Sr. no.	From		To		Air Cantents				Filter Paper	Dust Present	
	Date	Time	Date	Time	SO_2	NO_x	NH_3	H_2S		R.S.P.M	N.R.S.P.M
76	08/06/05	12:00	08/06/05	15:30	7	9	8	11			
77	08/06/05	16:00	08/06/05	19:30	6	11	11	8	19	215	314
78	08/06/05	20:00	09/06/05	8:00	6	12	9	9			
79	09/06/05	8:30	09/06/05	11:30	4	9	9	8			
80	09/06/05	12:00	09/06/05	15:30	6	10	8	8			
81	09/06/05	16:00	09/06/05	19:30	4	10	10	11	20	320	515
82	09/06/05	20:00	10/06/05	8:00	5	13	8	9			
83	10/06/05	8:30	10/06/05	11:30	7.1	73	23	16	0	332	1379
84	10/06/05	12:00	10/06/05	15:30	11	24	35	18	0	416	2804
85	10/06/05	16:00	10/06/05	19:30	7	14.1	10	13	0	272	422

In the Tractor / Machine repair work shop area, furnaces were arranged to burn the bricks. Surrounding of this location is existing Deonar Dumping Ground approach road, Ghatkoper Mankhurd Link Road, Sion Vashi Highway. All these roads are busy and considerable vehicular traffic flow always exists. Therefore, large quantities of suspended particals are present in the environment of this area some time more than the permissible limit. In this environment "burning of brick kiln" is done. Then cooling of furnace is also done. In these conditions it is noticed from the analysis that, there is practically no increase in the quantum of suspended particles.

In general, permissible limit of RSPM is 100mg/m3 & NRSPM is 300mg/m3. The actual suspended particles are always greater than the permissible limit.

	Burning of furnace		**Cooling of furnace**	
	20.05.05 to 26.05.05	3.06.05 to 7.06.05	27.05.05 to 31.05.05	8.6.05 to 9.06.05
Min. range of RSPM	332	209	230	215
Max.range of RSPM	580	318	405	320
Min. range of NRSPM	1165	276	1678	314
Max.range of NRSPM	2193	649	5707	5.18

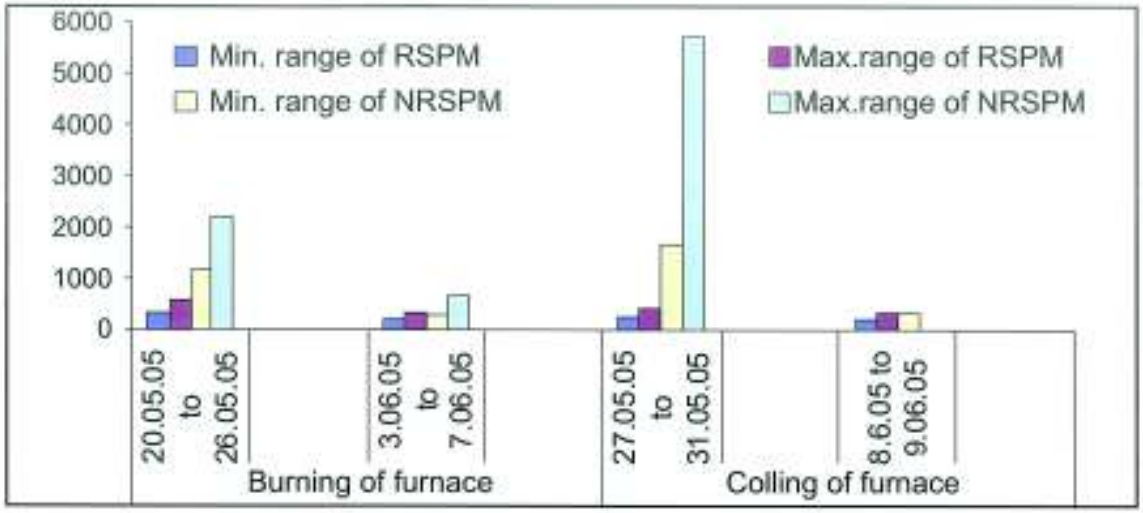


Photo 5.102 : Ambient air sampling.

Photo 5.103 : Ambient air sampling machine.

Photo 5.104 : Ambient air sampling machine.

Photo 5.105 : Ambient air sampling machine.

Photo 5.106 : Shed constructed by use of sample bricks.

Photo 5.107 : Shed constructed by use of sample bricks.

Photo 5.108 : Shed constructed by use of sample bricks.

Photo 5.109 : Inspection of Shed.

5.7 Analysis of results as per Combination of material :-

- MSW soil + agricultural soil, sample numbers (refer laboratory test results) 2, 10, 12, 20, 21, 22, 23, 54 & 58 were made in combination with the agricultural soil and MSW soil. In these samples the quantity of MSW soil varied from 38% to 90%, similarly, agricultural soil from 10% to 62%. After testing, bricks of all the samples, it showed that the minimum compressive strength is more than 10 kg/cm^2, and some samples showed strength up to 60 kg/cm^2. From this it indicates that properly burnt bricks give higher values of crushing strengths (27 to 60 kg/cm^2) and improperly burnt bricks give lower crushing strengths (10 to 20 kg/cm^2).

- MSW soil + agricultural soil + Fly ash F2, sample numbers (refer laboratory test results) 6,9,36,37,38,39,40 & 41 were made in combination of MSW soil with agricultural soil and Fly ash F2. In these samples the quantum of MSW soil varied from 48% to 74%. Similarly, agricultural soil varied from 4% to 29%, and Fly ash F2 varied from 11% to 42%. After testing, bricks of all the samples, it showed that the minimum compressive strength is more than 10 kg/cm^2, and some samples showed strength up to 60 kg/cm^2. From this it indicates that properly burnt bricks give higher values of crushing strengths (30 to 60 kg/cm^2) and improperly burnt bricks give lower crushing strengths (10 to 20 kg/cm^2).

- MSW soil + Fly ash F2, sample numbers (refer laboratory test results) 7, 8, 31, 32, 33, 34, 35, 51, 52 & 53 were made in combination of MSW soil and Fly ash F2. In these samples the quantum of MSW soil varied from 28% to 73%, and Fly ash F2 varied from 27% to 72%. After testing, bricks of all the samples, it showed that the minimum compressive strength is more than 10 kg/cm^2, and some samples showed strength up to 70 kg/cm^2. From this it indicates that properly burnt bricks give higher values of crushing strengths (30 to 70 kg/cm^2) and improperly burnt bricks give lower crushing strengths (10 to 20 kg/cm^2).

- Agricultural soil + Fly ash F2, sample numbers (refer laboratory test results) 18 & 19 were made in combination with agricultural soil and Fly Ash F2. In these samples, the compressive strength varied from 12.5 kg/cm^2 to 50 kg/cm^2

- MSW soil + Fly Ash F1, sample numbers (refer laboratory test results) 3, 4 and 15 were made with combination of MSW soil and Fly ash F1. In case of sample numbers 3, strength shown as high as 65 kg/cm^2 and in case of sample number 4 it is 12.5 kg/cm^2.

➢ Bricks made only with the MSW.

Sample number14 was made on experiment basis only with 100% of MSW. However, after burning we could not get any good bricks and all bricks were broken. Hence, it indicates that the bricks cannot be made only with the MSW and some additive like agricultural soil, fly ash is very essential to make the brick by use of MSW.

➢ Bricks made only with Fly Ash F1.

Sample number16 was made by use of 100% of fly ash. It has shown strength between 30 kg/cm^2 and 40 kg/cm^2 and it is indicated that good bricks could be made by use of Tata Fly Ash.

➢ Bricks made only with Fly Ash F2.

The Sample number17 was made by use of 100% of Fly Ash from Reliance Energy, it has shown compressive strength between 20 kg/cm^2 and 27 kg/cm^2 and it indicated that the bricks could be made by use of 100% of this Fly ash F2.

5.8 Statistical Analyses of Breakages of Bricks:-

The time for which the molded bricks were kept for drying is found to be varying. Similarly, percentage of Kachcha bricks damaged is found to be varying. The details in descending order are as follows :-

Sample No.	Total time of drying of moulded brick	No. of unburnt bricks	No. of damaged unburnt bricks	% of damaged unburnt bricks
2	21	915	105	11.48
1	20	827	125	15.11
3	20	785	138	17.58
5	18	851	250	29.38
6	17	1106	306	27.67
7	14	1014	200	19.72
9	14	1036	150	14.48
10	14	839	161	19.19
11	14	808	203	25.12
17	14	535	25	4.67
18	14	532	76	14.29

Sample No.	Total time of drying of moulded brick	No. of unburnt bricks	No. of damaged unburnt bricks	% of damaged unburnt bricks
51/1	14	950	385	5.62
51/2	14	775	385	5.62
4	13	956	381	39.85
8	13	1062	152	14.31
12	13	757	152	20.08
51/3	13	728	385	5.62
13	12	724	20	2.76
51/4	12	832	385	5.62
52/1	12	870	205	4.77
51/5	11	821	385	5.62
52/2	11	864	205	4.77
52/3	11	878	205	4.77
14	10	270	11	4.07
51/6	10	815	385	5.62
52/4	10	830	205	4.77
15	9	582	75	12.89
16	9	486	258	53.09
33	9	110	13	11.82
51/7	9	835	385	5.62
52/5	9	857	205	4.77
53/1	8	878	157	4.54
23	7	105	7	6.67
31	7	121	5	4.13
32	7	111	8	7.21
34	7	105	3	2.86
19	6	366	8	2.19

Sample No.	Total time of drying of moulded brick	No. of unburnt bricks	No. of damaged unburnt bricks	% of damaged unburnt bricks
20	6	132	12	9.09
22	6	199	33	16.58
24	6	15	0	0.00
35	6	102	2	1.96
21	5	194	30	15.46
25	5	16	0	0.00
36	5	126	15	11.90
26	4	12	0	0.00
27	4	16	0	0.00
38	4	108	13	12.04
41	4	113	28	24.78
28	3	16	1	6.25
37	3	120	11	9.17
39	3	113	19	16.81
40	1	102	21	20.59
53/2	8	878	157	4.54
53/3	8	961	157	4.54
53/4	7	763	157	4.54
54/1	7	917	10	0.27
54/2	5	952	10	0.27
54/3	4	922	10	0.27
54/4	1	908	10	0.27
55	5	107	0	0.00
56	5	106	0	0.00
57	5	107	0	0.00
58	5	119	0	0.00

The time for which the bricks were kept for burning is found to be varying. Similarly, percentage of burnt bricks damaged is found to be varying. The details in descending order are as follows:-

Sample No.	No. of bricks	No. of hours of burning	No. of good bricks	No. of damaged bricks	% of Good bricks
51	5431	259.00	2849	2582	52.46
53	3303	214.00	2102	1201	63.64
52	4094	212.30	2506	1588	61.21
35	120	169.00	115	5	95.83
8	914	168.30	350	564	38.29
34	102	168.30	81	22	79.41
37	109	168.30	88	21	80.73
38	95	168.30	73	22	76.84
39	96	168.30	43	53	44.79
32	103	168.00	89	14	86.41
33	107	168.00	87	20	81.31
36	111	168.00	76	35	68.47
31	116	167.45	89	27	76.72
7	814	167.30	556	258	68.30
17	310	167.30	245	65	79.03
20	120	167.30	108	8	90.00
23	98	167.15	86	12	87.76
21	164	167.00	92	72	56.10
22	166	166.45	92	74	55.42
5	601	166.30	403	198	67.05
4	575	166.00	333	242	57.91
18	456	165.30	417	39	91.45
1	702	165.30	370	332	52.71
2	810	165.30	501	309	61.85

Sample No.	No. of bricks	No. of hours of burning	No. of good bricks	No. of damaged bricks	% of Good bricks
6	800	165.30	342	458	42.75
3	647	164.30	369	278	57.03
54	3689	164.30	1253	2436	33.97
19	358	145.10	262	116	73.18
13	504	145.00	0	504	0.00
16	228	145.00	152	76	66.67
10	678	144.30	76	602	11.21
9	886	144.00	450	436	50.79
12	605	144.00	107	498	17.69
14	259	143.30	0	259	0.00
15	507	143.30	0	507	0.00
41	85	143.30	47	38	55.29
11	605	143.00	375	230	61.98
40	81	141.15	67	14	82.72
26	12	98.15	8	4	66.67
25	16	97.30	-	-	-
24	15	97.00	13	2	86.67
28	15	96.30	14	1	93.33
27	16	96.00	16	0	100.00
57	107	90.20	85	22	79.44
58	119	90.00	108	11	90.76
56	106	88.55	80	26	75.47
55	107	88.00	68	39	63.55

5.9 Typical Observations:

Since beginning it has been observed that, after burning of the bricks made from the mix of MSW, agriculture soil or fly ash, bricks are bulging out and disintegrating during its cooling process i.e. after about 3 to

4 days from stoppage of burning. After marathon discussion along with the team members it is felt that the bulging and disintegrating may be due to high content of calcium. It is also felt that during the cooling process the differential cooling might be taking place between calcium and the remaining material of the bricks thereby the calcium expands and stresses are created which expands the bricks, and ultimately break the bricks. Thereby in view of achieving controlled cooling process the burnt bricks were kept in the water in a submerged position before it becomes completely cool. Thereafter, observations were made and it is found that the bricks kept in water did not break or bulge. To support this analogy the bricks were analysed during the cooling process for content of calcium oxide and the results were corroborating the apprehension as it is observed that there is changes in contents of calcium oxide as it cools. The details of the samples tested and content of the calcium oxide is as follows :-

Brick No.	Length cm	Width cm	Height cm	Wt. in gm	% Oxide			
					5.3.05 CaO	7.3.05 CaO	9.3.05 CaO	10.3.05 CaO
20	21	9	6	2060	0.56	2.26	1.1	0.56
21	20	9	6	2205	0.56	1.68	1.68	0.56
22	22	10	6	1890	2.8	1.68	0.56	0.56
23	22	9	6	2150	0.56	1.68	0.56	1.12

Immediately after opening the kilns 10 bricks each of all samples of burnt bricks were sent to V.J.T.I. for testing. One burnt brick of each sample was sent to the Environmental Laboratory of Thane Municipal Corporation at Kanhaiya Nagar, Thane. Immediately, after kilns are opened 50 Nos. of burnt bricks of each sample were kept in the water, out of which 10 bricks of each sample were kept under water for 24 hours, other 10 bricks were kept for 7 days, remaining bricks remained in the waters for one month. As the bricks of different kilns were put in the water on different dates, dates of submerging them in the water were written in oil paint on each sample consisting of 50 bricks.

Out of above samples, the bricks of sample nos. 13,14 & 15 disintegrated into soil after submergence in the water. The disintegration took place after 20 to 24 hours. The bricks of other samples were found good and did not disintegrate. After opening the kilns, the good bricks and of

damaged bricks each sample were stacked separately. A paper showing mix proportions, dates wrapped in plastic cover were kept on each stack.

A paper showing mix proportions, dates wrapped in plastic cover were kept on each stack.

The submerged bricks were taken out of water and were kept in the sunlight for drying.

5.10 Compressed Block - From MSW:-

It was decided to explore possibility of making compressed blocks by mix of MSW soil, cement, coarse & fine aggregate in various combination. As Shri Ringshia of Hindustan Block Mfg. Co. was already involved in this research work. He was requested to manufacture compressed blocks by use of MSW with other conventional ingredients. Accordingly the MSW soil samples from Deonar Dumping Ground sent to his factory at Taloja. The blocks were manufactured by use of MSW soil in various proportion along with coarse and fine aggregate and cement. The proportion of various material is as follows :

Mix	Coarse Agg.(CA)		Fine Agg.(FA)		MSW soil		Total Wt.	C/A Ratio
	Wt. (kg)	% of Total	Wt. (kg)	% of Total	Wt. (kg)	% of Total		
I	68	30%	90	40%	67	30%	225	12
II	68	30%	112	50%	45	20%	225	12
III	68	30%	135	60%	22	10%	225	12

CA - Metal <10mm size
FA - Crushed sand
C/A - Cement Total Weight Ratio

The above blocks were tested for 21 days compressive strength and water absorption is as follows :

Mix	Compressive strength in kg/cm^2	% water absorption
I	35	5.15
II	55	4.80
III	63	4.85

As decided during the workshop held on 9.12.2004 a group was formed under the leadership of Shri Narendra Patel, President, Builders'

Association of India, along with Shri Rajendra J. Ringshia, Hindustan Block Mfg. Co., Shri Nikesh Shah, Environmentalist, and the team members of research work for exploring the possibility of making compressed blocks using debris and fly ash. The meeting of this team was held on 11.1.2005. During this meeting Shri Ringshia showed above blocks manufactured by him from the decomposed garbage and also he narrated the procedure followed by him along with its strength. Prof. G.B. Chaudhari has suggested to consider debris powder and MSW soil 10mm down in various proportions for block making. Percentage metal aggregate can be reduced and cement contents also can be reduced so that about 50 kg/cm^2 to 100 kg/cm^2 compressive strength of blocks can be achieved.

Accordingly following mixes were tried with debris.

Mix	Coarse Agg.(CA)		Fine Agg.(FA)		Debris		Total Wt.	C/A Ratio
	Wt. (kg)	% of Total	Wt. (kg)	% of Total	Wt. (kg)	% of Total		
I	180	30%	420	70%	0	0%	600	12
II	120	20%	420	70%	60	10%	600	12
III	90	15%	420	70%	90	15%	600	12
IV	60	10%	420	70%	120	20%	600	12
V	0	0%	420	70%	180	30%	600	12

CA - Metal <10mm size
FA - Crushed sand
C/A - Cement Total Weight Ratio
Debris - Pulverised to less than 12mm size.

The above blocks were tested for 21 days compressive strength and water absorption is as follows :

Mix	Compressive strength in kg/cm^2	% water absorption
I	86	3.20
II	75	3.80
III	69	4.10
IV	65	4.00
V	62	4.50

Following mixes were tried with the mix of Debris & Fly Ash (F2).

Mix	Coarse Agg. (CA)		Fine Agg. (CA)		Debris		Fly Ash (F2)		Total Wt.	C/A Ratio
	Wt. (kg)	% of Total	Wt. (kg)	% of Total	Wt. (kg)	% of Total	Wt. (kg)	% of Cement		
I	95	15.8%	415	69.2%	90	15%	5	7%	600	12
II	100	16.7%	410	68.3%	90	15%	10	14%	600	12
III	105	17.5%	405	67.5%	90	15%	15	21%	600	12
IV	110	18.3%	400	66.7%	90	15%	20	28%	600	12

CA - Metal <10mm size
FA - Crushed sand
C/A - Cement Total Weight Ratio
Debris - Pulverised to less than 12mm size.

The above blocks were tested for 21 days compressive strength and water absorption is as follows :

Mix	Compressive strength in kg/cm^2	% water absorption
I	60	4.25
II	65	4.40
III	70	5.45
IV	88	6.10

From above following conclusions are drawn.

- Compressed block with MSW soil.

As percentage of MSW increases from 10% to 30% with respect to weight of aggregates, the strength of compressed block decreases from 63kg/cm^2 to 35kg/cm^2. Similarly water absorption increases from 4.85% to 5.15%.

- Compressed block with Debris.

As percentage of Debris increases from 0% to 30% with respect to weight of aggregates, the strength of compressed block decreases from 86kg/cm^2 to 62kg/cm^2. Similarly water absorption increases from 3.2% to 4.5%.

- Compressed block with Debris and Fly Ash (F2).

The quantum of Debris remains same for all sample (15%) and as

percentage of Fly Ash (F2) increases from 7% to 28% with respect to weight of cement, the strength of compressed block increases from 60kg/cm^2 to 88kg/cm^2. Similarly water absorption increases from 4.25% to 6.1%.

5.11 Chemical Analysis of burnt bricks :-

As observed in the mix design that the chemical content of mix of MSW soil and agricultural soil or fly ash has shown that the chemicals present are not in the range of chemicals available in brick clay and agricultural soil. However all the 47 combinations from which bricks were made have shown that brick can take shape and the burnt bricks compressive strength varies from 10kg/cm2 to 60kg/cm2. Therefore it is felt that the chemical analysis of burnt bricks could be essential to compare with brick clay and agricultural soil results. Accordingly brick samples of burnt bricks of sample number 51, 52, 53 and 54 were sent to ETA Lab, Fort, Mumbai for chemical analysis and the results are as follows :

Sample	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	Cao %
51	55.63	19.34	13.93	8.10
52	53.62	18.59	14.01	10.97
53	50.98	17.83	13.30	15.01
54	54.30	17.24	15.40	9.25
Brick Clay	36.00	19.96	13.45	5.19
Agri. Soil	47.00	32.00	18.80	6.80

From the above result it is seen that the bricks manufactured with the mix of MSW soil and Fly ash (F2) (sample number 51, 52, 53) and using MSW soil and agricultural soil (sample number 54) has shown that the silica and calcium oxide is more and alumina and ferric oxide is close to chemical content of brick clay.

5.12 Samples of Leachate :-

The test results on leachate samples are given below :-

Sr. No.	Test Parameters	Sample No. 1 TP 14	Sample No. 1 TP 20
1	pH	7.31	7.56
2	Total solids; mg/L	12650	10087

Sr. No.	Test Parameters	Sample No. 1 TP 14	Sample No. 1 TP 20
3	Total Suspended solids; mg/L	4182	3280
4	Chlorides; mg/L	1380	1450
5	Chemical Oxygen Demand; mg/L	10400	8100
6	Biochemical Oxygen Demand; mg/L	4400	3600

From the above results it is seen that :-
pH of leachate ranges between 7.3 to 7.6, total solids range between 10000 to 13000 mg/L, soluble chlorides range between 1300 to 1500 mg/L.

5.13 Heavy Metals :-

The test results of heavy metals present in MSW are given below :-

Nature of the Sample. : Municipal Solid Waste.
Date of Collection. : 12.02.2005.

Sr. No.	Parameters	Obtained Result			
		Municipal Solid	In soil	Tata Ash	Dahanu Ash
1	Lead	14	4.93	3.03	3.98
2	Iron	2008	4902	Nil	1614
3	Zinc	547	211	1.24	140
4	Copper	33	25	0.381	6
5	Sodium	996	519	1106	4733
6	Calcium	77829	12758	83224	2024
7	Chromkium	34	111	38	31
8	Cadmium	0.635	0.128	0.306	0.055

Note - All values are in ppm.

From the above results it is seen that :-
The percentage of soluble heavy metals are well within permissible limit and are existing in traces.

6. MSW AS RESOURCE

6.1 As mentioned in Chapter 4, earlier the material excavated from trial pits were sieved to segregate 10 mm down and up size material which could be effectively used for making bricks.

The details of quantum of material in percent are as follows :-

Trial Pit	0 to 1 mtr		1 to 2 mtr		2 to 3 mtr		3 to 4 mtr		0 to 4 mtr	
	>10 mm	<10 mm	>10 mm	<10 mm	>10 mm	<10 mm	>10 mm	<10 mm	>10 mm	<10 mm
1	39	61	50	50	57	43	57	43	51	49
2	50	50	63	37	50	50	53	47	35	45
3	67	33	67	33	75	25	67	33	69	31
4	40	60	50	50	67	33	50	50	50	50
5	50	50	50	50	50	50	60	40	53	47
6	50	50	40	60	33	67	50	50	41	59
7	50	50	50	50	50	50	60	40	53	47
8	50	50	60	40	50	50	53	47	53	47
9	50	50	50	50	67	33	50	50	55	45
10	50	50	50	50	60	40	55	45	54	46
11	50	50	50	50	50	50	55	45	51	49
12	50	50	40	60	33	67	50	50	43	57
13	50	50	55	45	43	57	57	43	51	49
14	62	38	48	52	50	50	29	71	43	57
15	56	44	33	67	60	40	44	56	47	53
16	-	-	-	-	-	-	-	-	-	-
17	50	50	40	60	44	56	50	50	46	54
18	58	42	55	45	64	36	67	33	62	38
19	50	50	45	50	37	63	41	59	43	57
20	40	80	32	68	31	69	41	59	31	69

Trial Pit	0 to 1 mtr		1 to 2 mtr		2 to 3 mtr		3 to 4 mtr		0 to 4 mtr	
	>10 mm	<10 mm	>10 mm	<10 mm	>10 mm	<10 mm	>10 mm	<10 mm	>10 mm	<10 mm
Min.	39	33	32	33	31	25	29	33	31	31
Max.	67	61	67	68	75	69	67	71	69	69
Avg.	53	47	49.5	50.5	53	47	48	52	50	50

From the above table following observations can be made

1) Maximum quantum of 10 mm up size material is 75% and minimum 29%. Similarly Maximum quantum of 10 mm down size material is 69% and Minimum 25%.

2) The average quantum of 10 mm down size material which could be available for brick making varies from 47% to 52%.

3) Similarly average quantum of 10 mm up size material which could be available for recycling varies from 48% to 53%.

6.2 Sorting of 10mm and above size MSW materials :-

Seived and segregated 10 mm and above size material were again very carefully and meticulously divided into an individual material. From this following categories of material were found.

- Agricultural and garden foilage
- Tore Cloth pieces
- Broken Glasses
- Various types of Metallic objects
- Brick bats
- Rubber Waste
- Animal Bones
- Various types of Paper Waste
- Soil lump
- Various types of broken stones pieces
- Concrete pieces
- Broken Tiles marbles
- Lime stone pieces
- Various types of waste wooden pieces
- Coir
- Coconut curnails

- Various types of seeds
- Plastic carry bags
- Plastic rope
- Thick plastic material
- Damaged leather.

The quantum of availability of individual material were tabulated. From the data overall conclusions on quantum of availability of material can not be drawn. This is mainly due to haphazard dumping and rack picking of material at selected places in the dumping ground. Similarly if such material is smaller in size and mixed generally rack pickers neglects.

Trial pits were taken almost throughout the Deonar dumping ground, samples were drawn, analysis made and tabulated. The depth wise analysis of each material for all trial pits is as follows :-

- **Foilage**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	27.76	-	13.88
1 to 2	20.27	0.52	10.40
2 to 3	15.70	-	7.85
3 to 4	13.97	-	6.99
		Average	9.78

- **Cloth**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	11.99	-	6.00
1 to 2	7.22	0.39	3.81
2 to 3	33.40	-	16.70
3 to 4	13.87	0.52	7.20
		Average	8.43

➢ **Glass**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	2.71	0.22	1.47
1 to 2	3.99	0.20	2.10
2 to 3	2.21	-	1.11
3 to 4	2.94	0.11	1.53
		Average	1.55

➢ **Metal**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	4.06	-	2.03
1 to 2	4.45	0.08	2.27
2 to 3	2.84	-	1.42
3 to 4	2.96	-	1.48
		Average	1.80

➢ **Brick Bats**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	16.75	-	8.38
1 to 2	12.04	-	6.02
2 to 3	15.95	-	7.98
3 to 4	20.23	-	10.12
		Average	8.13

➢ **Rubber**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	1.81	-	0.91
1 to 2	1.36	-	0.68
2 to 3	3.66	-	1.83
3 to 4	1.74	-	0.87
		Average	1.07

➢ **Bones**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	2.33	-	1.17
1 to 2	1.93	-	0.97
2 to 3	1.11	-	0.56
3 to 4	2.63	-	1.32
		Average	1.00

➢ **Paper**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	8.82	-	4.41
1 to 2	8.93	-	4.47
2 to 3	2.87	-	1.44
3 to 4	2.05	-	3.03
		Average	3.34

➢ **Soil**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	13.43	2.41	7.92
1 to 2	8.95	1.54	5.25
2 to 3	50.38	1.10	25.74
3 to 4	13.48	0.81	7.15
		Average	11.52

➢ **Broken Crockery**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	2.43	0.31	1.37
1 to 2	7.74	-	3.87
2 to 3	4.74	-	2.37
3 to 4	5.86	0.25	3.06
		Average	2.67

➢ **Soil Lymps**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	11.85	-	5.93
1 to 2	16.06	-	8.03
2 to 3	25.26	0.25	3.06
3 to 4	41.40	-	20.70
		Average	11.82

➢ **Stone**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	46.00	10.04	28.02
1 to 2	54.53	7.67	31.10
2 to 3	60.61	6.51	33.56
3 to 4	61.34	5.89	33.62
		Average	31.75

➢ **Concrete Pieces**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	37.82	5.62	21.72
1 to 2	57.98	4.42	31.20
2 to 3	40.44	5.66	23.05
3 to 4	26.86	3.79	15.33
		Average	22.83

➢ **Tiles Marble Pieces**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	10.56	-	5.28
1 to 2	35.08	-	17.54
2 to 3	19.67	-	9.84
3 to 4	11.91	0.49	6.20
		Average	9.72

➢ **Lime Pieces**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	0.99	-	0.50
1 to 2	3.54	-	1.77
2 to 3	0.72	-	0.36
3 to 4	1.73	-	0.87
		Average	0.87

➢ **Wooden Pieces**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	7.64	0.75	4.20
1 to 2	6.64	1.32	3.93
2 to 3	10.93	0.78	5.86
3 to 4	9.39	0.29	4.84
		Average	4.72

➢ **Spoiled Coir**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	11.52	-	5.76
1 to 2	7.66	0.35	4.01
2 to 3	10.68	-	5.34
3 to 4	12.02	0.12	6.07
		Average	5.30

➢ **Coconut Curmail**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	5.79	0.50	3.15
1 to 2	4.00	-	2.00
2 to 3	5.93	-	2.97
3 to 4	4.28	0.13	2.21
		Average	2.58

➢ **Coal Pieces**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	2.16	-	1.08
1 to 2	1.22	-	0.61
2 to 3	0.96	-	0.48
3 to 4	0.60	-	0.30
		Average	0.62

➢ **Various Types of Seeds**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	2.77	-	1.39
1 to 2	1.99	-	1.00
2 to 3	2.11	-	1.06
3 to 4	1.64	-	0.82
		Average	1.07

➢ **Thin Plastic**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	13.72	0.88	7.30
1 to 2	16.57	0.91	8.74
2 to 3	17.03	-	8.52
3 to 4	16.60	0.32	8.46
		Average	8.26

➢ **Thick Plastic**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	6.68	0.15	3.42
1 to 2	2.69	0.07	1.38
2 to 3	1.50	-	0.75
3 to 4	4.00	0.13	2.07
		Average	1.91

➢ **Spoiled Leather Pieces**

Depth in mtrs	Maximum %	Minimum %	Average %
0 to 1	6.33	-	3.17
1 to 2	5.59	-	2.80
2 to 3	5.87	-	2.94
3 to 4	5.38	-	2.69
		Average	2.90

6.3 ECONOMICS

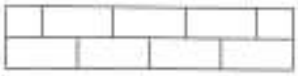
Froam above analysis it can be observed that about 50% of excavated material from Dumping Ground is having grain size less than 10 mm. therefore, can be used for brick making. Remaining 50% contains variety of material, many of which has good value. On enquiry with the Organization viz. Stree Mukti Sanghatana working for rag-pickers, it is found that the rate of each item varies on its quality and quantity. Similarly, wherether it is sold at wholesale or retail market. Present rates communicated by this organization is as follows.

Sr. No.	Particular	Wholesale Rate	Retail Rate
1	Tore cloth pieces	2.00	1.50
2	Broken Glass	1.50	1.00
3	Metallic Objects	7.00	5.00
4	Paper Waste	2.50	1.50
5	Plastic Carry bag	2.00	1.50
6	Plastic Rope	2.50	2.00
7	Thick Plastic	8.00	6.00

If 1000 Kg. of material is excavated, about 500 Kg. can be used for making bricks, which will produce about 250 bricks and provide value in terms of the selling bricks. Remaining 500 Kg. have various material even with rate given by Organization, it will have good value. The cost analyis is as follows.

Sr. No.	Perticular	Total Qty. in Kg.	% of mate -rial	Actual Qty. in Kg.	Whole sale Rate in Rs./kg.	Amount in Rs.	Retail Rate Rs./ Kg	Amount in Rs.
1	Tore cloth pieces	500	8.34	41.70	2.00	83.40	1.50	62.55
2	Broken Glass	500	1.55	07.25	1.50	10.88	1.00	07.25
3	Metallic Objects	500	1.80	09.00	7.00	63.00	5.00	45.00
4	Paper Waste	500	3.34	16.70	2.50	41.75	1.50	25.05
5	Plastic Carry bag	500	8.26	41.30	2.00	82.60	1.50	61.95
6	Thick Plastic	500	1.91	09.55	8.00	18.24	6.00	57.30

From the above table it can be seen that from 1000 Kg. excavated material will provide 250 Numbers of bricks may be at present rate of Rs. 1.50 per brick, it will be 250 x Rs. 1.50 = Rs. 375/-. Similarly, resalable material provides Rs. 300/-. Total Rs. 675/-.



7. CONCLUSIONS

7.1 From the initial three experiments :-

- MSW at dumping ground gets converted into soil. Conversion of compostable material in to soil requires 3 months to 1 year and may take large time or it may not get converted for material like plastic, metal, glass, bones, etc.
- From the MSW soil formed the building bricks could be made by use of conventional processes.
- These bricks satisfies the standard prescribed under I.S.Code.
- These bricks has similar strength and water absorption as that of normal bricks.
- There is huge market for these bricks within the City limit thereby for making bricks considerable amount of MSW will be quarried out thereby creating space for fresh. This will ultimately solve the problem of dumping ground and its expansion.
- The process does not cause any environment damage like an air pollution etc. however it will stop soil erosion of the agriculture field.
- This will create very good opportunity for employment of skilled and unskilled persons.

7.2 Drawing sample from Deonar Dumping ground and analysing it :-

- The detail field study is very essential to identify the type and amount of material available.
- About 50% of MSW excavated at any location is found lesser than 10mm in size thereby can be used for making the bricks.
- The remaining 50% of material is also very useful as it contains various kinds of recyclable material and if it is segregated properly it would be very useful product and fetch a good value.
- MSW has deficiency in silica, alumina and ferric oxide and calcium oxide as compared to the brick clay. similarly the quantum of finer material is less. These deficiencies could be removed by addition of fly ash from Thermal Power Station or

agricultural soil.

- Heavy metals like chromium, lead, copper, zinc in MSW are present in traces.
- On the basis of microbiological analysis it is seen that precautions in terms of cloth mask, gloves, gum boot etc. to the labourers will be essential while making the bricks from the MSW. Regular health check up of the people working in this field is also advisable.

7.3 Brick Making :-

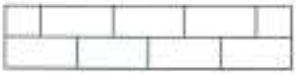
- The brick cannot be made exclusively from MSW, however, by addition of agricultural soil or fly ash to the minimum extent of 10% the bricks can be made which satisfies the required standard.
- It is very essential to segragate the material quarried by use of 10 mm size sieve, however, it is found that the material which initially shown grain size more than 10mm also disintegrate by drying and exposure to environment.
- the process of thorough mixing, allowing soaking is very important.
- On making brick blocks the proper drying, burning and allowing cooling need to be properly controlled.
- Very experienced personnel needs to be employed for all these activities.
- The handling of bricks before and after burning needs to be carried out very carefully to avoid its damages.
- During these experiments the cost of making brick varies from Rs. 1.00 to Rs. 4.00 per brick.
- Considering requirement of bricks in the city the process of manufacturing needs to be mechanized.
- On mechanization or even with conventional process if bricks are manufactured in large quantity the cost may be around Rs. 1.00 per brick.
- It is to mention that normally the cost of regular brick in the market is varies from Rs. 1.80 to Rs. 2.50 per brick.

- Presently bricks are coming in city by transport from almost 70 to 80 kms distance and by virtue of making bricks at dumping ground the transport will reduce, therefore savings in fuel, reduction in fuel emission which leads to reduction in cost of bricks and protection of environment.
- The room constructed by use of these bricks at Deonar dumping ground about 2 year back has shown very good result.
- Ambient Air Samples collected during the burning of bricks shows that all values of SO_2 and NOx and SPM are within the permissible limit.

7.4 Benefits :-

- Huge quantum of MSW will be used.
- Expansion of dumping ground will stop thereby no requirement of new land for dumping ground.
- It will facilitate extensive segregation and use of recyclable material.
- Provides solution for conversion of complete MSW into useful products.
- The recyclable material will provide very good value.
- The fly ash will be used in huge quantity.
- The cost of brick will be very less.
- The bricks will be available in huge quantity and as per requirement.
- The manufacturing process will take place at single location thereby complete quality control can be maintained.
- The size and shape of brick can be made as per requirement of client.
- Mechanisation will facilitate manufacturing even during monsoon which is not the case with normal bricks.
- Barranization of agriculture field will stop to great extent.
- Due to stoppage of expansion of dumping ground the damage to the environment will also stop.
- There will be saving in fuel and reduction in fuel emission.
- Exploitation of labourer will be stopped.

- At the end, this research work provides very innovative and extremely environment friendly solution to almost all problems created by two major solid waste i.e. MSW and fly ash.



8. INTERACTION WITH STAKE HOLDERS

8.1 Meeting was held at the office of Shri A.K. Jain, Sr. Adviser, SWM Cell, AIILSG, Andheri (West), when the following decisions have been taken:-

1) To conduct two workshops, 1st by end of November, 2003 and 2nd in May, 2004. The representatives of the following organisations will be invited.

   NEERI, CBRI, MOEF, CPCB, MPCB, SICON, MMRDA, CIDCO, MSEB, BSES, Tata Thermal Power Station, YUVA, National Productivity Council, etc.

2) To prepare a concept paper and send it by 30.9.2003 to all participants and receive response from them by 15.10.2003. Thereafter invitation will be sent by the end of October, 2003.
3) For taking trial pits and bores agency is required to be fixed for which prepare a document, short list the quotationers and calling of quotations shall be done by end of October, 2003.
4) Identification of locations for trial pits/bores at Deonar Dumping Ground by first week of October, 2003.
5) Starting of work by 10.12.2003.
6) Completion of work by 10.3.2004.
7) From 10.12.2003 to 10.1.2004 5 trial bores, from 10.1.2004 to 10.3.2004, 20 trial bores.
8) Testing of samples in the laboratory from December, 2003 to April, 2004.
9) Air samples testing by V.J.T.I. by 15.11.2003.
10) Preparation of mix design from April 2004 to October 2004.
11) To make brick blocks and burning in November, 2004.
12) Testing of burnt bricks by December, 2004.

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8.2 Letter from Shri Ratnakar Gaikwad, (I.A.S.) (Commissioner) on 25.03.2003 to Shri. S.S.Shinde.

Thank you very much for your D.O.letter No. MDB/1967/FAX dated 10.03.2003.

I am happy to note that the successful experiments have been conducted to make bricks from the decomposed garbage at Deonar Dumping Ground. I would strongly recommend formation of cooperative societies of educated unemployed who can be entrusted with the said work and if it is found feasible, please

inform me accordingly so that the concerned District Deputy Registrar, cooperative Societies would be asked to get in touch with you.

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8.3 Meeting held on 20.9.2003 at 10.00 AM in the E-Ward Conference Hall

The following were present for the meeting:-

Sr.No.	Name	Designation
1	Shri V.Y. Joshi	D.M.C.(SE)
2	Dr. P.P. Bhave	Faculty, VJTI
3	Shri D.R. Mohol	Dy.Ch.E.(SWM)(ES)
4	Dr. M.G. Karmarkar	Associate Professor (Microbiology), KEM Hospital.
5	Shri D.M. Shrotriya	E.E.P. to Ch.E.(SWM)
6	Shri D.L. Shinde	E.E.(Roads) (ES)
7	Shri S.G. Bhujbal	E.E.(Spl.)Z-II
8	Shri Mukadam	E.E.(Spl.)Z-I
9	U.N. Munidhar	A.E.(Soil Mech.)
10	Shri P.D. Gandhi	A.E.(Asphalt)
11	Shri Pramod N. Kalme	S.E.(Civil)
12	Shri G.G. Jadhav	Dy.H.S.Z-I
13	Shri B.R. Beldar	Dy.H.S.Z-V
14	Shri Jadhav,	AHS M/E
15	Shri M.S. Shaikh	Supervisor, DDG
16	Shri N.B. Achrekar	Ex.D.M.C.(E)
17	Shri M.R. Shah	Ex.Ch.E.(SWM)
18	Shri G.P. Vora	Ex.Ch.E.(SWM)
19	Shri S.N. Gundekar	J.O., DDG.
20	Shri K.N. Vaidya,	Brick Manufacturer

At the outset D.M.C.(Z-I) welcome the members for participating in the meeting and explained in detail the efforts made for making

construction bricks from the Municipal Solid Waste. DMC said that after inspection of Deonar Dumping Ground site we thought that we can make construction bricks from the MSW and that we started experiments of making construction bricks since August, 2002. DMC said that as per the information received from Octroi Deptt., daily about 350 trucks of bricks are coming in Mumbai City.

While explaining the experiments carried out at Deonar Dumping Ground DMC said that all the things dumped at dumping sites get converted into earth naturally. Glass, plastics, bones, take some more time. First experiment was started with the help of workers from Wada working in bricks manufacturing activity. Fine grain material was separated after blending the earth. The bhatti was burnt for 6 to 7 days. After opening the same it is found that the bricks of inside layers were very strong than the outside layers. It was an encouraging experiment. Thereafter, second experiment was carried out with the help of people from Matheran and the third experiment of about 1 lakhs bricks with help of Vasai people is recently completed. No outside earth was used in the 3rd experiment. 50% to 60% bricks found of good quality and it can be certainly said that if the outside earth is used, good quality bricks can be made from the Solid Waste and definitely we can do some constructive work for the MCGM.

Recently, the presentation was made before the MMR-Environment Improvement Society on 19.8.2003 and they have agreed to extend financial support for further research. Prof. Chaudhari, of VJTI and Shri A.K. Jain, Sr.Adviser, All India Institute of Local Self-Govt., are the senior leaders in this team. Fund will be received to AILSG and will be used through them.

In further research, detail soil investigation will be done by taking trail pits upto 3 mt. depth and trial bores upto 10 mt. depth and soil sample of each meter depth will be collected and tested at different laboratories. Thereafter, bhatti of 6000 bricks from each soil sample will be arranged. In this field soil investigation is an important activity and the same will be started by the end of November,2003. A workshop at national level is also arranged on 28.9.2003 at AILSG, Andheri.

Thereafter, D.M.C.(Z-I) requested the invitees to give their opinions, suggestions, etc., since they were associated with the waste disposed at Deonar Dumping Ground and are well aware of all the characteristics.

1) **Dr. Bhave, VJTI** - Microbiological study, and study of licheds factor is to be done. Characterisation of 50 to 60 samples will also be done. Soil will be added in different ratio for testing before final product. After all tests are done findings will be very useful.

2) **Dr. Karmarkar, Associate Professor (Microbilogy) KEM Hospital** - Since there may be many bacteria, viruses, etc., in the earth at dumping ground, there are more chances of infection to the people working in this field. Therefore, nature of these bacteria and capacity of their harm is required to be studied.

3) **Shri Mohol, Dy.Ch.E.(SWM)(ES)** - Gave information about Deonar Dumping Ground and the activities going on there. About 600 M.T. Solid Waste including earth, debris, stones, all type waste material, industrial waste, decomposed food, etc., is dumped daily at Deonar Dumping Ground. 10 different zones have been made for dumping waste material. Plantation is also done. Rag pickers of Stree Mukti Sanghatana are doing segregation of waste. Vermicomposting of about 5 MT garbage is done. Deonar dumping ground is now at its saturation level and now there is a problem of dumping of solid waste. Project of waste to energy is in process.

4) **Shri Kshotriya, EEP to Ch.E.(SWM)** - Ch.E.(SWM) could not come due to another important meeting. He said that MMR-Environment Improvement Society has approved the proposal. He suggested to have a permanent laboratory at Deonar Dumping Ground.

5) **Shri V.Y. Joshi, D.M.C.(SE)** - This is a very good project. Good quality earth is available below 3 mt. depth. Trial bores should be taken instead of taking trial pits. There is much ash due to the frequent fire at Deonar Dumping Ground. This ash is not useful for making bricks. Therefore, fire preventive measures are required to be taken.The required strength is not seen in these bricks due to salty water. Dumping pattern should be finalised and garbage should be dumped according to the pattern.

6) **Shri N.B. Achrekar, Ex.D.M.C.(E)** - Due to generation and accumulation of gas in between two layers the fire incident occurs at Deonar Dumping Ground frequently. To Control such fires is very difficult since there is no approach to the fire spot. Air quality monitoring is done through mobile van. It is necessary to reduce biodegradable waste to eliminate the fire problem. Silt and debris should not be sent to dumping ground.

7) **Shri G.P. Vora, Ex. Ch.E. (SWM)** - In 1983 an experiment of making bricks was carried out but due to major contents moisture the bricks could not take much strength. He said that 5% to 7% of our staff has skin diseases, 15% staff has asthma problem and some have blindness. Many employees died due to different diseases before superannuation. He suggested to stabilise the area properly.

8) **Shri M.R. Shah, Ex.Ch.E. (SWM)** - He handed over copy of the report prepared by him. He has elaborated some of the points like fire prevention, construction of concrete roads, level of roads, formation level of dumping ground, etc., in this report. He assured to extent all support to this project and said that the project should be self driven. He also suggested that only the waste generated by households be dumped at Deonar Dumping Ground as mentioned in the MMC Act.

9) **Shri Gandhi, A.E. (Asphalt Laboratory)** said that pathological microbiology study is required to be done.

D.M.C.(Z-I) gave thanks to all for giving valuable information. Shri Mohol, Dy.Ch.E.(SWM) (ES) assured to give some data base of the area. DMC enquired whether natural segregation of waste is done by rag pickers. Shri M.R. Shah told that this information is available with AILSG. There are many complaints from the local residents about Deonar Dumping Ground and the matter has gone in the Court. The MCGM has given affidavit in the court that adequate precautions will be taken to prevent fire at Deonar Dumping Ground. Shri Shotriya, EEP to Ch.E.(SWM) assured to give information of all court cases about dumping grounds in Mumbai.

D.M.C. (Z-I) gave thanks to all and requested to give information within seven days. The meeting then terminated.

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8.4 Letter dated 18.10.2003 from Shri M.R. Shah, Former Chief Engineer (SWM), MCGM -

Dear Shri Shinde,

A discussion was arranged in your office on 20th August,2003 to find out an alternate solution for disposal of Municipal Solid Waste in which the undersigned was also invited alongwith Senior Officers of MCGM and experts from V.J.T.I. We could establish good dialogue to understand the objective of individual participants and also their experience, which can be used for the benefit of MCGM.

At the outset, I would like to compliment you for arranging the debate on this vital subject. During my tenure ship in MCGM and also during post retirement period, I am keeping myself active with this subject issue. I have also written on this issue particularly making this subject more clear in terms of legal, technical aspects other than local problems. One of the Write-ups which are based on implementation criteria as per Notification issued by Govt. of India on 25th Sept.2000 is enclosed herewith covering important topics. I am sure this will give some clarify in terms of wholesome approach.

Let me have your reaction, if any on the said write up.

With regards,

Yours sincerely,
(M.R. SHAH)

8.5 Letter dated 22nd September, 2003 fro THE CATHEDRAL & JOHN CONNON CHOOL Middle School, Maharashi Dadhichi Marg, Mumbai-400001.

Dear Mr. Shinde,

Thank you very much for taking time off from your busy schedule to attend the inauguration of the flowerbeds that the Nature Club has built from bricks made from garbage, the joint venture that we have taken up with the B.M.C.

As you are aware the children of the Nature Club were involved in a 'Sponsor a Brick', project in order to collect funds to pay for the bricks made by the BMC. We had earlier sent you Rs.10,000/- as payment towards the same.

The children of the Nature Club will, over a period of time monitor the state of the bricks and send you a report. We hope that in doing so the Cathedral and John Cannon Middle School Nature Club will be playing an active role in the BMC experiment, 'Bricks from garbage'.

Thanking you once again.

Yours sincerely,

Ms. J. Vaz,
Headmistress.

8.6 Meeting on 13/1/2004 at 3.00 PM in the chamber of Shri A.K.Jain, Sr.Advisor, AILSG. Shri S.S. Shinde, DMC, MCGM; Prof. G. B. Chowdhari, VJTI; Shri Mukadam, Executive Engineer, MCGM (Retd.), Shri Pramod Kalme, Civil Engineer, MCGM, Shri Kishor Vaidya and Shri Shelke, Brick manufacturers, were present.

In the meeting it was decided to frame a time schedule to perform different activities. The same is as follows:-

	Details of activity	Responsible Officer	Due date
1	Sending letter to MMRDA showing details / break up of expenditure to be incurred for different activities.	Shri G.B.Chowdhari, Asstt.Prof.V.J.T.I.	14/1/2004
2	**(a)Taking trial pits/bores** Preparation of quotation document showing details such as specification, qualification/details of trial pits, bores machinery required, bills of quantities, estimated cost, amount of earnest money, security deposit, mode of payment, retention money, plans showing spots for trial pits, bores, details of time schedule, date of start, date of completion etc.	Professor G.B. Chaudhari, V.J.T.I.	24/1/2004
	(b) Inviting quotation The tender Committee will invite quotations on the address of All India Local Self Govt. and V.J.T.I. from the firms export in this field. The tender Committee shall be comprised of i) Shri A.K.Jain, Sr.Advisor ii) Shri G.B.Chowdhari, Professor, V.J.T.I., iii) Shri S.S.Shinde, DMC, MCGM and Member Secretary Shri A.Y. Mukadam, Ex.Engineer, MCGM (Retd.). During meeting the time schedule of activities is fixed as under :- i) Press note for inviting quotations. ii) Opening of quotations. iii)Appointment of agency and issue of work order. iv)Date of starting of work. v) Date of completion of works.	Shri A.K. Jain, Sr. Adviser, AILSG. Prof. G.B. Chaudhari and Shri A.Y. Mukadam	28/1/2004 10/2/2004 10/2/2004 15/2/2004 15/3/2004

	Details of activity	Responsible Officer	Due date
	(c) Supervision of trial pit and bore works will be done by Shri A.Y. Mukadam, Executive Engineer, MCGM (Retd.) and Shri Pramod Kalme, Jr. Engineer, MCGM.		

	Details of activity	Responsible Officer	Date of starting	Date of Completion
3	**Testing of samples and bricks etc.** a)Environmental & chemical test.	Dr. P.P. Bhave, Lecturer, Civil Engineering, VJTI	20.2.2004	20.3.2004
	b) Microbiological and biological test.	Dr. Karmarkar, Associate Professor, G.S. Medical College, KEM Hospital.	20.2.2004	20.3.2004
	c) Physical testing of samples of soil taken at various pits and bores.	Dr. Karmarkar, Associate Professor, G.S. Medical College, KEM Hospital.	20.2.2004	30.9.2004
	d) Making of brick blocks, mixing blending of various types of soil samples and also fly ash in various proportions in laboratory and testing the same in laboratory.	Prof. G.B. Chaudhari, VJTI	20.2.2004	30.9.2004
	e) Manufacturing of bricks involving all processes such as blending of soil, drying of bricks, burning of bricks, testing of bricks.	Shri S.S. Shinde, Dy. Municipal Commissioner, MCGM.	10.10.2004	30.11.2004

	Details of activity	Responsible Officer	Date of starting	Date of Completion
4	Seminar for seeking advice, guidance from various experts, various agencies.	Shri S.S. Shinde, Dy. Municipal Commissioner, MCGM.	20.3.2004	
5	Preparation of periodic reports and submitting to MMRDA. i) 1st Report. ii) 2nd Report. iii) 3rd Report.	Shri G.B. Chaudhari and his team.		30.3.2004 30.6.2004 30.9.2004

Further it has been decided :-

6	To involve Maharashtra Pollution control Board as member of the team
7	To include Dr. Karmarkar, Associate Professor of G.S. Medical College, KEM Hospital in the team to carry out Microbiological and biological tests on various soil samples.
8	Shri Kishor Vaidya from village Wada, Thane District, who is experienced in brick making industry, will work as full time worker and will assist Prof. G.B. Chowdhari, in various activities of the project.
9	As far as the accounting system is concerned, it was decided that as the payments are to be received by All India Institute of Local Self Govt., the accounts of expenses shall be maintained by the Accounts Deptt., of AILSG. The bills will be scrutinised by the Project Monitoring Committee and will be certified and released by the Accounts Unit of AILSG.
10	It is decided to request MMRDA to release initially an amount of Rs.7 lakhs by 30.1.2004 so as to be ready with the finances for the impending expenditures. The second installment of Rs.5.50 lakhs will be required by 30.6.2004.

8.7 Visit was arranged on 10.4.2004 at Deonar Dumping Ground for inspection of field activities particularly taking trial pits and trial bores at 10.00 AM. The following were present :-

1) Shri Pendharkar, Director, MMR-Env. Improvement Society.

2) Shri Ramnathan, Member, Sub Committee,
3) Dr. Tondwalkar, Environmentalist, MMRDA.
4) Shri Ahivale, Sub Regional Officer, Maharashtra Pollution Control Board.
5) Prof. G.B. Chaudhari, V.J.T.I.
6) Shri S.S. Shinde, D.M.C.(Z-I)
7) Shri Mukadam, O.S.D.
8) Dr. Karmarkar, Associate Professor, GS Medical College (KEM hospital)
9) Shri. Pramod N. Kalme, Civil Engineer,
10) Shri Kulkarni, E.E.(SWM)
11) Shri Beldar, Dy.H.S. Z-V and others.

Before starting inspection, a review of the works done till date was taken. It was explained by Prof. Chowdhari and Dr. Karmarkar that the test on the samples drawn have been started. Dr. Karmarkar explained that detailed microbiological analysis is required to be done in view of various infectious material disposed of at Dumping Ground. Shri Pendharkar stated that the report prepared under the Metropolitan Environment Improvement Programme on the study of Deonar Dumping Ground, may also be considered during this study. It was informed that 15 trial pits out of 20 have been completed. 3 trial bores out of 5 have been completed and 4th is in progress. All the field activities will be over by 15.4.2004. Shri Pendharkar enquired about the percentage of soil available after sieving on which one of the sample was shown which shows that out of 26 kg. total sample of 20 kg is found to be 10mm and down size material which could be useful for making bricks.

During the visit 2 nos. of trial pits viz. trial pit No. 9 and 16, were shown and 3 nos. of trial bores, where the work was completed, were shown. At the end trial bore No.2 was shown where drilling work was in progress. Here sample drawn of 4" dia pipe sealed with vax on both the ends was shown. Thereafter the brick kiln of 3rd experiment was shown to them. At the end they showed satisfaction towards the work carried out.

8.8 Meeting held on 4.5.2004 at 11.00 AM at the Office of the Dy. Municipal Commissioner (Zone-I) 3rd floor, E-Ward Office Building, Byculla, Mumbai-400 008.

The following were present :-

1) Shri A.K. Jain, Sr. Adviser, SWM, AIILSG, Andheri (W).

2) Prof. G.B. Chaudhari, V.J.T.I.
3) Dr. P.P. Bhave, V.J.T.I.
4) Shri S.S. Shinde, D.M.C.(Z-I)
5) Dr. Karmarkar, Associate Professor, GS Medical College (KEM hospital)
6) Shri Mukadam, O.S.D.
7) Shri Pramod Kalme,

The issues like physical sorting and separation of decomposed material, pollution point of view, testing for effect on environment, electric kiln, press technology, etc. discussed in the meeting. Also issue regarding utilization of debris from MSW to make tiles, bricks by adding cement etc., was discussed.

1) Prof. Chaudhari said that electricity can be used on large scale to burn the bricks instead of using the coal. If the electric kiln is installed the problems like air pollution will be eliminated. It is decided to visit the electric kiln at Taloja.
2) Prof. Chaudhari further said that compressed bricks through Press Technology, can be made from the fly ash by mixing lime to certain extent. It is decided to visit Dahanu area and Kolkatta Foundry to see this technology.

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8.9 On 26.6.04 at 10.00 AM a visit was arranged to Tata Thermal Power Station to see the fly ash. During the visit the following were present :-

Sr.No.	Name	Organisation
1	Shri S.S. Shinde	DMC Z-I,MCGM
2	Prof. G.B. Chaudhari,	V.J.T.I.
3	Shri C.D. Chore	A.C. M/West
4	Shri P.J. Patil	A.C. M/East

Initially, we met GM, Tata Thermal Power Station and explained the project of making construction bricks from the mix of decomposed MSW and agricultural soil. It is further explained to them that we are planning to use fly ash instead of agricultural soil so that both wastes could be used and there will not be further degradation of environment by virtue of removal of top soil for making bricks. It has been informed that they use fuel called EURO coal as well as oil for generation of power. The residual of this coal is only

about 1% therefore, quantum of fly ash is also less. The whole fly ash is taken away by some agency for land filling and other use. Similarly for making granules of the size of 20 mm and down which is being used for pavement, etc. The GM has agreed to provide fly ash free of cost at Deonar Dumping Ground for this project

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8.10 Shri Nanik Rupani, Chairman, Indian Merchants Chamber, a presentation on making construction bricks from the decomposed garbage was made on 6.8.2004 at 6.00 PM. The following were present during this presentation:-

Sr.No.	Name	Organisation
1	Shri. A. K. Jain	Sr. Adviser, SWM, AIILSG
2	Shri S. S. Shinde	DMC Z-I,MCGM
3	Prof. G. B. Chaudhari,	V.J.T.I.
4	Dr. P. P. Bhave	V.J.T.I.
5	Prof. Dr. Karmarkar	K.E.M.
6	Shri. Markandeya	Chief Engineer, SWM, MCGM
7	Shri. A.Y. Mukadum	Ex. Eng. MCGM
8	Shri. Pramod N. Kalme	Civil Engineer, MCGM

Shri Nanik Rupani, Chairman, Indian Merchants Chamber, initiated the discussion and Shri A.K. Jain introduced the theme. Thereafter, Shri S.S. Shinde, gave presentation as under:-

RESEARCH ON MAKING CONSTRUCTION BRICKS FROM MUNICIPAL SOLID WASTE

IN URBAN AREA

Due to increase in population and change in life style, the quantum of Solid Waste has increased and created problem of disposal.

Difficulties

- Dumping grounds are at super saturation level.
- Non availability of new low lying area for disposal of solid waste.
- People leaving around dumping grounds are facing tremendous problems of pollution, nuisance, health, etc.
- Ground water pollution.
- Danger to marine life.

Environment (Protection) Act, 1986. Municipal Wastes (Management & Handling) Rules, 2000.

- Improvement of existing landfill sites. (31.12.2001)
- Identification of landfill sites for future use and making site ready for operation. (31.12.2002)
- Setting up of waste processing and disposal facilities. (31.12.2003)

- Various methods of processing MSW deal with the fresh MSW.
- Effective use of dumped/ decomposed MSW lying in huge quantity at dumping ground is very essential.

In view of using dumped/ decomposed MSW which is almost like soil, three experiments of making construction bricks have been conducted at Deonar Dumping Ground.

Details of studies

Quarrying of dumped/decomposed matter, segregating plastic, metal rags, etc., and sieving of remaining soil to segregate fine grain material.
Mixing it manually with the soil brought from agriculture field & making of brick blocks.
Arranging Bhatti & burning by use of coal.

Photographs of Study No.1

Photographs of Study No.1

Photographs of Study No.2

Photographs of Study No.2

Photographs of Study No.3

Study Report

	Study 1	Study 2	Study 3
• No. of bricks made	3800	1350	70,000
• Agriculture soil added	10%-15%	NIL	10%
• Period of Bhatti burn with paddy foliage.	6 days	10 days	12 days
Test results as per IS 1077			
Water absorption	<25%	18.56%	Testing
• Compressive strength.	>35 Kg/cm²	65.58 kg/cm²	was not done. 30 Kg/cm²

Outcome of studies

- Construction bricks can be made from the mixture of decomposed MSW and soil.
- These bricks can be made by using indigenous process.
- These bricks are technically sound.
- For manufacturing of 1000 bricks about 4 to 5 MT of decomposed garbage will be consumed.

- Encouraged with the outcome formed Research Team of experts from MCGM, AIILSG, VJTI, G.S. Medical College is formed and prepared research proposal.
- Presented before the MMR Environment Improvement Society for financial assistance.
- Society agreed to provide Rs.12.5 lakhs.
- Time schedule is 1½ years.

Project Proposal

- Characterisation of dumped/ decomposed MSW.
- Preparation of mix design with natural soil and fly ash.
- Study of Environmental impact.
- Study of microbiological import.
- Study of financial viability.

FIELD ACTIVITIES

- Taken 20 trial pits of 4M x 4M x 4M depth and 5 bores of about 10M depth spread evenly at Deonar Dumping Ground.
- Collected soil samples from agricultural field from which the regular bricks are made.
- Collected fly ash samples from Tata Thermal and MSEB Power Stations.

Sampling

- 80 soil samples at various depth are drawn from trial pits.
- 46 undisturbed soil samples are drawn from the trial bores.
- Leachate samples are taken wherever found.

Characterisation of MSW divided into

- Geotechnical
- Environmental
- Microbiological

Geotechnical Analysis

- Sorting.
- Grain size analysis
- Atterberg Limits

Mix design

Since bricks cannot be made only from decomposed garbage, number of combinations of decomposed garbage with various percentages of natural soil and mainly with fly ash are designed for making construction bricks. Efforts are made to use at least 70% decomposed garbage.

Environmental Studies

- Chemical composition particularly Silica, Alumina, CaO, Iron, Oxide, etc.
- Pollution index particularly Chloride, Sulphate, PH, T.O.C., etc.
- Leachates for its chemical compositions.

Microbiological Analysis

Detection of Pathogen's

- Bacteriological,
- Fungal,
- Myco bacteriology and
- Parasitology.

Industrial aspects

- Processing for making bricks.
- Reprocessing for recyclable material.

Material

- 60% to 70% of decomposed material can be processed for making bricks.
- Remaining 30% to 40% consisting of material like plastic, cloths, paper, broken glass, iron, bones, ceramics and stone aggregates, etc., can be reprocessed.

Market

- As per Octroi record about 20 lakhs bricks are brought daily in Mumbai for Construction Industry.
- There is huge market in reprocessing industry.

Turnover from

- Brick making will be about Rs.150 Crores per annum.
- Reprocessing of recyclable material would be about Rs.50 Crores per annum.

Employment Generation

- It will stop exploitation of labourer which is happening presently at various brick making sites.
- About 1 million man days per annum will be generated through this industry.

Environmental Studies

- Chemical composition particularly Silica, Alumina, CaO, Iron, Oxide, etc.
- Pollution index particularly Chloride, Sulphate, PH, T.O.C., etc.
- Leachates for its chemical compositions.

Prevention of Environment degradation

- For manufacturing bricks the top layer of agriculture field soil is removed, which is very fertile with full of nutrients.
- As per estimates for manufacturing of 20 lakhs bricks the soil of 5 acres of land is removed.
- For Mumbai annually 1825 acres of land is made barren.

Prevention of Environment degradation.....contd.

- No further land is required for dumping ground.
- Stoppage of endanger to the environment by virtue of expansion of dumping ground.
- Transport of bricks will reduce from about 70 KM to 20 KM.

Through this research work we are confident that the solution to urban MSW and problems created by it, will be resolved to a greater extent by providing useful product like construction bricks & recyclable material.

TEAM

Leader

- Shri G.B. Chaudhari, Asstt. Professor, VJTI.

Members

- Shri A.K. Jain, Sr. Adviser, AIILSG.
- Shri S.S. Shinde, Dy.Municipal Commissioner, MCGM.
- Dr. P.P. Bhave, Lecturer, Civil Engineering, V.J.T.I.
- Dr.M.G. Karmarkar, Associate Professor, G.S. Medical College.
- Shri A.Y. Mukadam, Executive Engineer, MCGM.(Retd)

THANKS

There were questions and answers session after the presentation. Apart from this there were about 150 people invited by IMC.

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8.11 Letter from Shri Nanik Rupani (President, Indian Merchants Chamber) on 07.08.2004 to Shri. S.S.Shinde.

On behalf of the Indian Merchants Chamber and on my own, i wish to express our sincere thanks to you for visiting the Chamber and addressing the representatives of the business community of Mumbai on "Solid Waste Disposal Management " Making Construction Bricks from Decomposed Garbage on 6.08.2004 at 5.00 p.m. in its premises.

You made a comprehensive presentation on the innovatives Brick making project, which has the participation of engineers, professors and researchers. We do hope that this environmental friendly project, which will not only make use of garbage but will also create space in the dumping ground, will be successful in Mumbai.

We assure you of our fullest cooperation in this project in particular and Mumbai Development in general. I am enclosing a photograph taking on the occasion as a remembrance

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8.12 A one day workshop arranged on 9th December,2004 at All India Institute of Local Self Govt. in connection with the above subject matter.
At the outset Shri A.K. Jain thanked Shri Soli Arceiwala, Founder President, Indian Environment Association, for accepting to inaugurate this workshop at a very short notice. Shri A.K. Jain, requested the participants to introduce themselves.

The following representatives participated the workshop:-

Sr. No	Name	Designation
1	Shri A.K. Jain,	Sr. Advisor, SWM, AILSG
2	Smt. Sneha Palnitkar	Professor, AIILSG
3	Shri S.S. Shinde	Dy. Municipal Commissioner, MCGM
4	Prof. G.B. Chaudhari	Asstt. Professor, I/c Head, Structural Engineering, V.J.T.I., Mumbai
5	Dr. P.P. Bhave,	Lecturer, Civil Engineering, VJTI, Mumbai.
6	Dr. M.G. Karmarkar	Associate Professor, GS Medical College, (KEM Hospital), Mumbai.

Sr. No	Name	Designation
7	Shri S.K. Bhalerao	Chief Engineer, MSEB, Maharashtra State Electricity Board, Prakashgad, Bandra (E), Mumbai-400 051.
8	Shri Narendra D. Patel	Chartered Engineer, Builders Association of India. Charter Engineer, 43/41, Tamrind Lane, Rajabahadur Building, Fort, Mumbai-400001.
9	Shri Rajendra J. Ringshia	Hindustan Block Mfg. Co., Basant Niwas, 14, Malviya Road, Vile-Parle (E), Mumbai-400 057.
10	Mr. Nilesh Patil,	Touch N Glow House Keeping Services, 22, Mudra Shopping Complex, Kacheri Road, Palghar (W), Dist: Thane-401404.
11	Smt. Jyoti Mhapsekar,	Stree Mukti Sanghatana
12	Shri M.R. Shah,	Ex.Chief Engineer (SWM), MCGM, FAX: 5600409
13	Shri R.R. Markendeya	Chief Engineer (SWM), MCGM,
14	Smt. Chandan Chawla	YUVA (Youth for Unity and Voluntary Action), 52/53, Nare Park Municipal School, Opp: Nare Park Ground, Near Shirodkar High school, Parel (E), Mumbai-400 012.
15	Shri S.R. Pawar	Dy. Municipal Commissioner, SWM, Kalyan-Dombivali Municipal Corporation.
16	Dr. Katole	O.S.D., MPCB. Maharashtra Pollution Control Board, Kalpa Taru Point, 3rd and 4th floor, Opp. Cine Planet, Sion Circle, Mumbai-400 022.
17	Shri Shirish Dedhia	Flat No.702, D-Wing, Amazon Bldg., Jairaj Nagar, Borivali (West), Mumbai-400 091.
18	Shri B.S. Gandhari,	Jr. Scientific Officer, Maharashtra Pollution Control Board, Kalpa Taru Point, 3rd and 4th floor, Opp. Cine Planet, Sion Circle, Mumbai-400 022.

Sr. No	Name	Designation
19	Shri S.P. Nande,	Executive Engineer, MSEB, Maharashtra State Electricity Board, Prakashgad, Bandra (E), Mumbai-400 051.
20	Shri Mukesh Shah	Environment Engineer, Builders Association of India, 43/41, Tamrind Lane, Rajabahadur Building, Fort, Mumbai-400001.
21	Shri Rathod	Jr. Engineer, MMRDA
22	Mr. Malcome Lobo,	Nandakhal Padai, Agasi, Virar, Dist Thane.
23	Shri S.B. Kardile	MPCB
24	Shri B.C. Kamble,	Asstt. Executive Engineer, CIDCO.
25	Shri B.S. Rathod	CIDCO
26	Shri A.Y. Mukadam	Retired Executive Engineer, MCGM.
27	Shri. Pramod N. Kalme	Civil Enginner, MCGM,

Shri Jain said that the Solid Waste Management is very important subject for all Municipal Councils and Corporation and therefore, Central Government has enforced the Solid Waste Management Rules and made it mandatory that solid waste should be scientifically disposed off. There are dumping grounds in all cities. Population is growing due to urbanisation and solid waste is also increasing in every city and big size land is not available in the for disposal of MSW. Due to Environment Regulations and Coastal Regulations the lands in the Mumbai City cannot be utilised for disposal of MSW and also MSW cannot be dumped near another City. In short, we have to use the existing available land fill site for disposal of MSW by making its proper planning. We reduce MSW going to landfill site by segregating the waste at source. Most of the dumping sites are nearing saturation. It is now essential to mine the stabilised material decades ago and find out whether we can sell it after some processing. Thereby capacity and size of existing landfill sites could be increased. Now local and foreign consultants have also recommended this factor. Shri S.S. Shinde, who is Deputy Municipal Commissioner in Municipal Corporation of Greater Mumbai, has tried some experiments to find out whether construction bricks can be made from the decomposed garbage and found that this is a prima facie case for converting stabilised waste into brick. If we come to

definite conclusion in making bricks from the waste, not only capacity and life of landfill site will be increased but environment degradation can also be avoided. After getting these preliminary results, naturally we wanted to have very detail research carried out in order to give some scientific conclusion to make bricks from the MSW. We all are facing lot of strain on this issue. This issue was also discussed in the meeting of MMR Environment Improvement Society and they were very generous to give financial assistance to this project to carry out this research work. Now the research work is going on and in this workshop we would like share our experience. We will take opinion of all participants including brick manufactures and also brick consumers. It is hoped that at the end of workshop we will be able to come out with definite conclusion both scientifically and economically acceptable. Thereafter, Shri Jain requested Shri S.S. Shinde to give his presentation.

Shri S.S. Shinde, gave power point presentation. He said that due to the increase in urban area and change in life style the, quantum of waste has been increased.There are many difficulties in disposal of solid waste since the existing landfill sites are nearing super saturation and non availability of new sites for disposal, people staying around these sites are facing tremendous problems like air pollution, nuisance, ground water pollution, danger to marine life, etc. The Environmental (Protection) Act 1986 which promulgated rules for MSW which gave dead line for improvement landfill sites by 31.12.2001. Identification of landfill sites for future use and making sites ready for operation by 31.12.2002. Setting of waste disposal facilities by 31.12.2003. Various methods of processing MSW have number of draw backs. Effective use of dumped/decomposed MSW lying in huge quantity at dumping ground is very essential. In view of using decomposed MSW, three experiments of making construction bricks were conducted at Deonar Dumping Ground. First of all the dumped material was quarried out thereafter segregated plastic, metal, rage, etc., and sieved the remaining soil to segregate fine grain material. Then it was mixed manually with the soil brought from agriculture field and made brick block. Thereafter these blocks were burnt by using coal. Some photographs of 1st, 2nd and 3rd experiments showing the above activities and the MPCB staff taking air samples were shown. Earlier Municipal Commissioner Shri K.C. Srivatsava, also visited the site. He explained the study report in detail. In study No.1, 3800 bricks made by adding 10 to 15% agricultural soil. Bhatti

was burnt with paddy foliage for 6 days. In Study 2, 1350 bricks were made without adding any soil. Bhatti was burnt for 10 days. In Study 3, 70,000 bricks made by adding 10% agriculture soil. The bricks were then tasted as per IS code 1077. We found that construction bricks can be made from the mixture of decomposed MSW and soil by using indigenous process. These bricks are technically sound. For manufacturing 1000 bricks about 4 to 5 MT of decomposed garbage will be consumed. We encouraged very much with the outcome and formed Research Team of experts from MCGM, AIILSG, VJTI, G.S.Medical College, prepared research proposal and presented before the MMR Environment Improvement Society for financial assistance. The Society agreed to provide assistance of Rs.12.5 lakhs and the time schedule is fixed is 1½. The project proposal consists of characterisation of dumped/decomposed MSW, preparation of mix design with natural soil and fly ash, study of Environmental impact, study of microbiological import and study of financial viability. Here we have added fly ash because generation and disposal of fly ash and garbage is continuous process. Fly ash is also available in huge quantity which has not consumed years together, hence we have added 10% to 20% fly ash instead of natural soil. We decided to study environmental aspect, microbiological organism of MSW, financial viability of bricks made from garbage. Garbage consists of various microbiological organisms which are likely to infect the people handling garbage.

We taken 20 trial pits of 4 M x 4 M depth and 5 bores of about 10M depth spread evenly at Deonar Dumping Ground, collected soil samples from agricultural field at Thane and Panvel area from which the regular bricks are made, collected fly ash samples from Tata Thermal Power Station and MSEB Power Station. 80 soil samples at various depth are drawn from trial pits, 48 undisturbed soil samples are drawn from the trial bores and leachate samples are taken whenever found. Characterisation of MSW divided into Geotechnical, Environmental and Microbiological. In Gotechnical analysis we did sorting, grain size analyais atterberg limits. Efforts have been made to use atleast 70% of the garbage with different components and prepared mix design. We carried out environmental studies consisting of chemical composition particularly silica, alumina, CaO, iron, oxide, etc., Pollution index particularly Chloride, Sulphate, PH, T.O.C., etc., and Leachates for its chemical compositions. We have carried out Mycrobiological analysis, Detection of Pathogen's bacteriological,

fungal, Myco bacteriology and paracitology. Wherever there is garbage there is housing industry. There are two parts of Industrial Aspects i.e. Processing for making bricks and Reprocessing for recyclable material. 60% to 70% of decomposed material can be processed for making bricks. Remaining 30 to 40% consisting of material like plastic, cloths, paper, broken glass, iron, bones, ceramics and stone aggregates, etc., can be reprocessed since it is a very useful prodoct for some body else. We have caterised the remaining material into 13 to 15 categories and found that huge material is available in the decomposed garbage. About 350 truckload of bricks are coming in the city daily. If we manufacture 350 truckload bricks daily there will be turnover of Rs.150 Crores per annum and recycling industry will become biggest industry through this project. There is exploitation of labour working in brick industry in the rural area. Under this project the exploitation of labour could be stopped. Since there is no alternative, for making bricks top fertile agricultural soil is removed which is an important parameter of environment degradation. This could be saved if this project is taken into hand.. Dumping ground itself can be a reprocessing component. No further land would be required for dumping ground. Distance for transportation of bricks will be reduced from 70 KM to 20 KM. Through this research work we are confident that the solution to urban MSW and problems created by it, will be resolved to a greater extent by providing useful product like construction bricks and recyclable material. For this research work we have formed a team under the leadership of Shri G.B. Chaudhari, Asstt. Professor, VJTI and the members are Shri A.K. Jain, Sr. Adviser, AIILSG, Shri S.S. Shinde, Dy. Municipal Commissioner, MCGM, Dr. P.P. Bhave, Lecturer, Civil Engineering, VJTI, Dr. M.G. Karmarkar, Associate Professor, GS Medical College and Shri A.Y. Mukadam, Retired Executive Engineer, MCGM.

After the presentation, Shri A.K. Jain said that from this presentation it is seen that it is a major environmental issue of protecting our agricultural soil. One important issue is can we find substitute for making bricks. Disposal of fly ash is also a major issue before us. Some people are here who are making and marketing bricks and tiles. Then Shri Jain requested Soli Arceiwala, Founder President, Indian Environmental Association, to inaugurate the workshop.

Shri Arceiwala, first congratulated Shri S.S. Shinde and his team and said that this an excellent work, research is a dream and it has not started because of the public interest litigations. I am associated with the research works since very long. Firstly, as professor in VJTI, then as a Director, NEERI for few years and now in the MMR Environment Improvement Society. We have been receiving many proposals but unfortunately these are elementary school boy type proposals which we cannot push further and we have to disappoint the participants. Any one with the good proposal is always welcome. Mostly the research going on in this country is revalidation of some thing happens or its demonstration. Here you are making bricks from the solid waste. This is not only useful for India but for the whole World. You are taking useless product and making valuable product and therefore you are congratulated. People like you must be found in this country who are making value addition jobs. He further said that you are doing what we need for solving the environment problems. Disposal of fly ash is a big problem.

Smt. Sneha Palnitkar, Professor, AIILSG, also welcomes the project and said that they have started many Research and Development works. She assured that whatever support required will be extended by AIILSG for any good work.

Thereafter Dr. P.P. Bhave, gave presentation, when he explained the details of samples drawn and charactisation of the waste. MSW soil was sieved below 10mm and above 10mm in size. Both these factors were analysed in the laboratory for the bacteriological analysis in G.S. Medical College (KEM Hospital). Leachets samples were taken and analysed in the laboratory.

Professor G.B. Chaudhari, gave presentation and explained the experiments done. He said that 20 samples were analysised. If the soil is pressed forcibly under the new Press Technology, it can take shape. Thereafter we decided to prepare mix design. All samples of trial pits have been collected. In some samples fly ash from Tata Thermal Power Station and from Dahanu mixed.

After lunch, all members participated in question and answers, panel discussion. After detail discussion it was decided to form a committee

of the following members:-

1) Shri Narendra Patel, (Convener)
2) Prof. G.B. Chaudhari,
3) Shri S.S. Shinde,
4) Shri Bojoy Davis, YUVA,
5) Dr. Katol, MPCB.
6) Dr. Bhalerao, MSEB,
7) Mrs. Sneha Palnitkar
8) Shri Rajendra J. Ringshia

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8.13 Meeting held on 11.1.2005 at 3.00 PM at AIILSG, Andheri (West), when the following were present:-

Sr.No.	Name	Organisation
1	Shri. A. K. Jain	Sr. Adviser, SWM, AIILSG
2	Prof. G.B. Chaudhari,	V.J.T.I.
3	Shri S.S. Shinde	MCGM
4	Shri Nikesh P. Shah	Env. Co-ordinator
5	Shri Narendra Patel	Builders Association of India
6	Shri Santoshi Shinde	E.E., M.S.E.B.
7	Shri B.S. Gadhari	J.S. Officer, MPCB
8	Shri Rajendra Rungshia	Hindustan Block Mfg. Co.

During the meeting Shri Ringshia showed the samples of compressed blocks made from the decomposed garbage. He pointed out that the strength of these blocks is high. Shri Jain insisted that we should make blocks by pulvorised and segregated debris. Shri Ringshia pointed out that he should be given at least Five mix design so that he will be able to make the samples of blocks accordingly. In this regard it has been stressed that storage of debris in a pure form is very essential as normally it is seen that debris get adulterated and mixes with the garbage, thereby its use becomes difficult. Since the strength of compressed block made from the decomposed garbage is less it has been asked to examine whether it can be used for pavement and the open spaces around the building instead of on the road.

At the conclusion it has been decided that Shri Ringshia will prepare a compressed blocks of the debris as well as garbage with the various mix designs.

8.14 On 23.1.2005, we visited Koradi Thermal Power station of M.S.E.B. First we visited the factory of making compressed bricks of Mr. Vinu Paul, PAUL Bricks, at 57, Indora, Kamptee Road, NAGPUR-440 004. Here the bricks are made from mix of fly ash, sand, lime and gypsum. The process is particularly mechanised. Fly ash from Koradi Thermal Power Station is used for making bricks. While mixing the sand of about 40%, fly ash 40%, lime about 15% and at the end gypsum of 5% is added in mixure and mixed for about one minute. Thereafter, through the convenor belt it is carried upto the mold of bricks. In each mold there are 4 slots having size of about 230 mm x 100 mm x 100 mm i.e. brick size. The mix is poured into blocks one by one and then compressed with pressure of 36 MT on each block. Then such compressed brick is ejected from the mold make and then manully it is transported in the storage area. Such bricks are kept for about 20 days at the normal environment temperature and in summer water is sprinkled on it. It has been informed by Shri Vinu Paul, the proprietor of this Company that they get compress strength of about 100 kg\cu.m. on this brick.

Daily about one lakhs bricks are being manufactured by using 4 sets of such machines. He further stated that they also make a conventional brick of about 1.5 lakhs per day. They are the biggest manufacturers of the bricks in the Nagpur area. It has been further informed that in Nagpur about 15 lakhs of bricks are consumed daily. The breakage is about 3 to 5. As the fly ash is stored in huge quantity and also lying, there is a problem of pollution in the surrounding areas. It is observed that these bricks are giving very good strength and also uses the waste material like fly ash to the tune of 40%. However, use of other material like sand, lime and gypsum, the cost of brick is about Rs.3/- per number. Thereby it is found no economical as compared to the normal bricks which available at Rs.2/- per number. It has been further pointed out by Mr. Paul that the mind set up of people to use such compressed brick is required to be made of, as still there is feeling in the minds of people that the bricks made by use of conventional material and method are best. The fly ash brick is also very heavy as each brick could weigh about 3 to 4 kg. as compared to the weight of normal bricks i.e. 1.8 to 2.2 kg.

We have discussed our project of making bricks by use of decomposed garbage and agricultural soil/fly ash. The Dy. Chief Engineer in charge of Power Station and Shri Paul agreed to extend all cooperation for our work.

Thereafter, we visited the Head Quarter of NEERI and met Dr. D.V. Deshpande, Scientist and Sr. Asst. Director, NEERI, when numbers of his other colleagues were also present. We showed them Power Point presentation and thereafter we had long deliberations about chemical and environmental properties of the garbage, physical analysis, etc. It has been pointed out by Dr. D.V. Deshpande they have never done any work with view of using decomposed garbage and they have been working basically on use/converting fresh garbage.

They showed keen interest in our project and requested and requested to invite them when we will be conducting next workshop.

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8.15 On 29.1.2005 visit is arranged to the site of making bricks from the decomposed garbage at Deonar Dumping Ground, when the following were present:-

Sr.No.	Name	Organisation
1	Shri R.R. Markendeya	Chief Engineer, MCGM
2	Miss Uma Adusumilli	Chief, Planning Division, MMRDA
3	Shri S.P. Pendharkar	OSD, MMRDA
4	Prof. G.B. Chaudhari,	V.J.T.I.
5	Shri Rajendra Rungshia	Hindustan Block Mfg. Co.
6	Shri Nilesh B. Patil	Touch N'Glow, Palghar
7	Shri Samir Dadia	Dadia Construction
8	Shri Shirish Dadia	Dadia Construction
9	Shri Narendra Patel	Builders Association of India
10	Shri Nikesh P. Shah	Envoirnmentalist
11	Shri Avinash S. Kubal	Maharashtra Nature Park.

During this visit the kiln of mould No.1 was opened and samples were shown to all. It is found that these samples are brittle. It has been explained that this sample is made by us of 70% MSW, Agricultural soil 30%. The process of mixing of decomposed garbage, fly ash and

agricultural soil was shown. Similarly, making of wet blocks was also demonstrated. Shri Pendharkar pointed out that it is essential to find out the amount of garbage consumed for making bricks. Similarly, Miss Uma Adusumilli, insisted that we should examine the contents of arsenic and heavy metals in the garbage. They further stated that Thane Municipal Corporation has the facility of testing for heavy metals and Mrs. Pradhan is in charge of this laboratory.

Shri Narendra Patel, Builders Association of India, has pointed out that marketing of these bricks would not be problem and requested the brick manufacturers like Mr. Dedia to involve into it and make about 1 lakhs bricks initially. They further pointed out that Shri Dedia will make an application for making 1 lakhs bricks. Shri Nikesh Shah, environment expert appreciated the work and pointed out that this would be best project to eliminate the problems at dumping ground. Shri Markendeya, Ch.E.(SWM) has also participated in the discussion. Thereafter, the brick kiln arranged for sample No.8 was burn. At the conclusion Ms Uma pointed out that we should extend our study and examine all aspects of environmentally, commercially and marketing may be by inclusion of experts in this field. She further pointed out that in this regard, we can make a special proposal to them. She also pointed out that if the fund is required for making bricks at initial stage may be in the form of samples, MMR Environment Improvement Society will support it.

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8.16 Letter from Shri Nanik Rupani (President, Indian Merchants Chamber) on 09.02.2005 to Shri. S.S.Shinde.

On behalf of the Indian Merchants Chamber and on my own, I wish to express our sincers thanks to you for visiting the Chamber and addressing the representatives of the business community of Mumbai on "**Mumbai Development: Mumbai Municipal Corporation's Vision**" organized under the auspices of the IMC's City Development & Environment Committee on Tuesday, 8.02.2005 in the preemies of the Chamber.

We hope to receive your continued Co-operation in our future activities.

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8.17 In continuation to earlier visit on 29.1.2005, the visit was arranged on 12.2.2005 at 4.00 PM at the site of making bricks from the decomposed garbage at Deonar Dumping Ground, when the following were present:-

Sr. No	Name	Organisation
1	Smt. Uma Adusumilli	Chief, Planning Division, MMRDA
2	Prof. G.B. Chaudhari,	V.J.T.I.
3	Shri S.S. Shinde	MCGM
4	Shri Nikesh P. Shah	BAI Co-ordinator.
5	Shri Subhash Patil,	ALM Office
6	Smt. Uma Padhya	AIILSG SWM Cell
7	Mrs. Deepa Chatterji,	AIILSG SWM Cell
8	Smt. Indrani Malkani	AGNI
9	Shri Leo Fonseka	President, Marble, UN-Habitat Consultant.
10	Shri A.Y. Mukadam	Engineer In Charge
11	Smt. Pradhan	Pollution Control Office, Thane Municipal Corporation
12	Shri. Pramod N. Kalme	MCGM,
13	Shri Shirin Dadia	Civil Engineer, Sara Trading Co.
14	Shri Narendra Patel	Builders Association of India
15	Shri Santoshi Shinde	E.E., M.S.E.B.
16	Shri B.S. Gadhari	J.S. Officer, MPCB

The project was explained to Shri Leo Fonseka, UN-Habitat Consultant and others. All have showed keen interest and appreciated the work. Smt. Indrani Malkani from AGNI also has shown keen interest in purchase of these bricks which she would like to use for making flower beds around the roads in Malbar Hill area as a part of beautification. She further pointed out that Smt. Garware of Garware Architectural College would like to participate this project. She further pointed out that one of the Professors from this college would like to work along with the team. Similarly, teacher teaching Environment subject in the Cathedral school would also like to participate in this project. Smt. Pradhan took all information about this project and also taken samples for testing it for arsenic and heavy metals in their laboratory at Thane Municipal Corporation. Smt. Uma Adusumilli, Chief, Planning Division, MMRDA, again pointed out that we should

extend the work by including all environmental, commercial and market aspects in the research work for which she requested to make proposal to MMR Environment Improvement Society. Shri Narendra Patel as again reiterated that there would not be any problem in selling of these bricks. He pointed out that we should project this work at the International level as a "Carbon Credits" which is a new concept and likely to be a an important in all industries very soon

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8.18 On 20.2.2005 at 7.00 p.m., visit was arranged to the site of making bricks from the decomposed garbage at Deonar Dumping Ground, when burning of mix Nos. 1,2 and 4 was complete and of No.8 was in progress. The kiln of mix Nos. 5,6,9,10,12,14 and 15 was arranged and ready for burning. The kiln for mix Nos. 3,7,11,13 and 16 is being arranged. Shri Vaidya explained that for covering the sides, he requires about 1000 nos of burn bricks. Therefore, I paid him Rs.2,000/- to purchase such bricks from the market.

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8.19 On 26.2.2005, visit as arranged to the site of making bricks from the decomposed garbage at Deonar Dumping Ground. Prof. Chaudhari could not attend the visit as he was busy elsewhere. It was observed that some of the bricks of mix No.2 has been disintegrated. Similarly, most of the bricks of mix No.8 are also disintegrating

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8.20 On 29.2.2005, I visited the site of making bricks from the decomposed garbage at Deonar Dumping Ground along with Prof. Chaudhari. Shri Vaidya was present at site. On seeing that the burnt brick samples are disintegrating Prof. Chaudhari stated that the detailed chemical analysis of such disintegrated bricks are required to be carried out for which Smt. Pradhan of Pollution Control office, Thane Municipal Corporation, can be involved and she can be asked to analyse these bricks for various chemical contents. Shri Vaidya pointed that some bricks get disintegrated whereas other bricks do not. There are chances that it may be because of lime content in it and with the burning and cooling effect expansion and contraction of such lime takes place. Thereon it is felt that if we do not allow the lime to expand or contract but to get merged with the surrounding like cement it may give good result. Therefore, it has been decided that before it is completely cooled such bricks could be sub merged in a water thereby lime would mix with the water and cementing action takes place. Therefore, Shri Vaidya has been instructed to take 50 nos. bricks from each sample and

before they are totally cooled they should be submerged in a water in a pit made for making brick blocks. It has also been instructed that after the lapse of 24 hours, 3 days, 7 days and 14 days, the samples from such submerged 50 bricks should be taken out and kept under observation for disintegration. It has been further instructed to Shri Vaidya that he should send 15 samples of each mix to V.J.T.I. Laboratory for carrying out various tests. Prof. Chaudhari pointed out that he will be carrying out weathering analysis on such bricks by wetting and drying.

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8.21 In view of taking further decisions a meeting was held on 2.4.2005 at 4.00 PM, in 'E' Ward office chamber when the following were present :-

Sr.No.	Name	Organisation
1	Shri S.S. Shinde	DMC Z-I, MCGM
2	Prof. G.B. Chaudhari,	V.J.T.I.
3	Mrs. M.M. Pradhan	Thane Municipal Corporation.
4	Shri. Pramod N. Kalme	MCGM

During the meeting detailed discussion took place on the outcome of chemical analysis carried out by Mrs. Pradhan at TMC Laboratory on MSW, Agriculture soil, Tata Fly Ash, Dahanu Fly Ash. The outcome shown is as follows :-

Name of the Organisation : BMC
Nature of the Sample. : Municipal Solid Waste.
Date of Collection. : 12.02.2005.

Sr. No.	Parameters	Obtained Result			
		Municipal Solid	In soil	Tata Ash	Dahanu Ash
1	Lead	14	4.93	3.03	3.98
2	Iron	2008	4902	Nil	1614
3	Zinc	547	211	1.24	140
4	Copper	33	25	0.381	6
5	Sodium	996	519	1106	4733
6	Calcium	77829	12758	83224	2024
7	Chromkium	34	111	38	31
8	Cadmium	0.635	0.128	0.306	0.055

Note - All values are in ppm.

Since the bricks were disintegrating, the sample were sent on 5.3.2005 to find out chemical analysis particularly CaO and the results were as follows :-

Brick Nos.	Length cm	Width cm	Height cm	Wt. in gm	% Oxide CaO			
					5.3.05	7.3.05	9.3.05	10.3.05
20	21	9	6	2060	0.56	2.26	1.10	0.56
21	20	9	6	2205	0.56	1.68	1.68	0.56
22	22	10	6	1890	02.8	1.68	0.56	0.56
23	22	9	6	2150	0.56	1.68	0.56	1.12

During the detail discussion it is felt that due to high calcium in the Municipal Solid Waste as well as Tata Fly Ash, the bricks made from these two combination are disintegrating as it cools down. Similarly, however, the bricks made by the mix of Municipal Solid Waste and Dahanu Fly Ash do not show such phenomena to a greater extent as calcium is very low in Dahanu Fly Ash. It has been pointed out by Mrs. Pradhan that the contents of heavy metal are much less than the ample limits in all the components used for this experiment. Hence there is no harm in using MSW, Agricultural soil, Dahanu Fly Ash and Tata Fly Ash for making the bricks.

Dr. Karmarkar has submitted his report. At the conclusion, it has been decided that we should further conduct experiment of making bricks in combination of MSW, Dahanu Fly Ash and Agricultural soil.

8.22 On 7.4.2005, visit was arranged to the site of making bricks from the decomposed garbage at Deonar Dumping Ground was visited, when the following were present:-

Sr.No.	Name	Organisation
1	Shri S.S. Shinde	DMC Z-I,MCGM
2	Prof. G.B. Chaudhari,	V.J.T.I.
3	Shri Nikesh Shah	BAI Coordinator
4	Shri A.Y. Mukadam	MCGM
5	Shri. Pramod N. Kalme	MCGM
6	Shri Shelke	Brick Manufacturer
7	Shri Kishor Vaidya	Brick Manufacturer

As per the direction Shri Kishor Vaidya has segregated the bricks as per their mix design with mix Nos were shown good result. The number of bricks recovered are as follows:-

Sample No.	No. of bricks	Sample No.	No. of bricks.
1	350	13	-
2	481	14	-
3	258	15	132
4	313	16	225
5	85	17	397
6	422	18	431
7	536	19	242
8	330	20	72
9	420	21	72
10	111	22	66
11	355	23	69
12	87		

It is observed that the bricks made with the mix of Tata Fly Ash has not consistence in shape and got disintegrated. However, bricks made from MSW and Dahanu Fly Ash have retained the shape and also have radish colour. Similarly, bricks made with the combination of MSW, agriculture soil and Dahanu Fly Ash have also shown good out put. It was held that among these mixes the amount of damage was more and while discussing it is held that since we have been mixing it in the pit there were lot of leakages and mixing was improper. Hence M.S. Box of 3' x 4' x 1½' height was made and in this the following mixes will be tried:-

Mix No.	MSW	DFA	Agriculture soil.	No. of bricks made
31	7	3	-	121
32	6	4	-	111
33	5	5	-	110
34	4	6	-	105
35	3	7	-	102

Mix No.	MSW	DFA	Agriculture soil.	No. of bricks made
36	7	1	2	126
37	6	2	2	120
38	5	3	2	108
39	7	2	1	113
40	5	4	1	
41	6	3	1	

It has been decided that the best quality bricks from each sample will be sent to the laboratory at VJTI for their its strength which will be done by 12.4.2005. Similarly, the sample of MSW, Dahanu Fly Ash and agriculture soil alongwith the samples of unburn and burnt bricks from each mixes will be sent to Mrs. M.M. Pradhan, Pollution Control Officer, Thane Municipal Corporation, for checking its calcium contents.

At site, the mixing of mix No.33 was done (50% MSW + 50% DFA) in the M.S. Tray. It was found that by this way the mix becomes most homogenous and thereby the bricks will show very good results.

8.23 Building bricks & concrete blocks from Municipal Solid Waste (MSW)

Mr. Shinde, Dy. Municipal Commissioner of MCGM has taken up a novel and interesting projects study to convert selected Municipal Solid Waste (MSW) material for building construction.

As Chairman of Environmental Committee of Builders' Association of India, myself & Shri Nikesh Shah M.S. (Env.-USA) had an opportunity to participate in the project-study and our views are as under:

Brick making from MSW:-

MSW which has been deposited in dumping yards from years together has been converted into a soil. Mr. Shinde very rightly thought that if this soil can be utilised for making bricks, it will solve number of problems like.

1. Reduce considerable MSW volume and increase the life of dumping yard.
2. Fertile soil of agriculture farms which is used for making brick can be saved.
3. Supply of brick can be made easily available.

This is indeed novel idea of Mr. Shinde, but it required lots of detailed study,

which was conducted by him with the help of various organisations, associations & individuals.

Firstly it was checked & found that MSW taken out from reasonable depth does not have health hazardous problem. Then this soil was analysed & required ingredients and their different proportions were tried by making sample bricks. Observations about size, shape, strength etc. of such bricks. Such engineering analysis has been prepared and now good data banks has been established. Such bricks are used at various public places so that performance can be observed continuously.

The project study has proved that bricks can be prepared from selected MSW and by adjusting and adding the deficient ingredients, good bricks can be prepared from MSW & can be marketable.

Recommendations:-

1. Enterprener is to be selected to carry out the mass production and in initial stage proper guidance, support and facilities to be extended to make this venture successful.
2. BAI can help in giving market requirement, survey and marketing support.
3. It will be also preferable if,
   1) MCGM, MHADA, PWD, MMRDA etc. specify to use such bricks in their tenders (in initial stage certain % use).
   2) MCGM allow brick making plant on dump-yard it self.
   3) Environment dept. can extend financial support for further research on the subject.

Concrete Block Making from MSW:-

It is observed by MCGM concerned officers that about 2000 MT of construction debris per day is being transported & dumped in the dumping yard.

Mr. Shinde is making project study to utilise this MSW (in form of construction debris) to be converted into concrete block.

Construction debris is to be used as replacement of sand & stone chips. Every lot is having different sizes & proportion hence balance to be make up by adding required sand & stone chips.

Various concrete blocks made out of such MSW have given encouraging results. Detailed Engineering & Project viability study will be required, to consider following issues:

1. Whether ward wise such units be encouraged to save transport cost.
2. Centralised crushing plant to handle construction debris and its viability.
3. Technical, financial support and facility to manufacture such concrete blocks.
4. To give market support, specify in the tenders of Govt. authorities for the used of such blocks.

Conclusion:-

Mr. Shinde has come out with creative & novel idea of treating MSW and converting into building materials like bricks & concrete block.

In project study he has worked out detailed engineering with the help of Prof. Chaudhury of VJTI and manufactured number brick-batches with various proportions. Their cost, strength etc. are worked out and created good data bank. Small market trial has also given good encouraging report.

It seems that project study is successful and with some input from administration, mass manufacturing of bricks from MSW can be reality and MCGM will be the leader to convert MSW into brick making. Really, Wealth from the Waste.

Similar project study had to be initiated to convert construction debris into concrete blocks. Details engineering & data bank is being collected and it is hoped that it will be also successful concept.

(II) OBJECTIVES:

The main objective of the research was to demonstrate that environmentally reliable and appropriate solutions for Municipal Solid Waste (MSW) that has been decomposed over the years at the Municipal Landfills are available, On-Site, and in a manner that is scientific; logical; and demonstrable as well.

The other key objective that was considered for the research was to consider reducing the burden on the existing municipal landfills within the City / State.

If MSW can be reduced by reuse, the excavated and decomposed garbage then will create extra capacities within the existing landfills. This will further help the municipal authorities to effectively plan and meet the ever-increasing garbage and solid waste demands of urban populations within their jurisdiction.

It can be successfully demonstrated by this research project that when decomposed MSW was reused by adding and mixing with other solid wastes i.e. fly-ash and construction / building debris, useful and acceptable materials such as bricks, pavers, etc. can be prepared of realistically good quality and strength.

Subsequently, with certain modifications and further research such bricks, pavers, etc. can be suitably accepted and consumed by the construction / building industry as a ready material that can be used on a regular basis.

It was also noted that reuse of decomposed MSW with other solid wastes such as fly-ash and construction / building debris can alleviate in the topsoil conservation by reducing the use of top-soils that is typically required for making usual materials like red bricks used for constructions, etc. A very interesting outcome from this research study, indeed.

(III) OBSERVATIONS:-

(A) The Process:-

(1) The research was very extensive and exhaustive.

(2) Experts such as policy-makers, administrators, educationalist, manufacturers, environmentalists, representatives of various NGOs, etc. were involved in this research from the beginning.

(3) Detailed and methodical follow-ups, round-table conversations, etc. were held routinely to ensure the high quality of research materials was being generated for the future use.

(4) Regular on-site visits and studies at a municipal landfill site were conducted. These included:

(a) Selection of MSW (source, segregation, and quantity)

(b) Selection of other waste materials such as fly ash, construction / building debris, etc.

(c) Understanding the manufacturing process for bricks, pavers, etc.

(d) Follow-up on manufacturing procedures and evaluating the finished products

(e) Repeating the same, till desired results were achieved as per the experts' panel.

(f) Inviting experts and concerned people to further comment on the results and the material that were manufactured, on a regular basis.

(g) Combining and compiling all the data that were generated and analyzing it for the next batch and the further evaluations.

(h) The process repeated and narrowed down till the experts involved with the research project selected the desired materials.

(B) The Outcome:

(1) The bricks, pavers, etc. were made by using different mixes of MSW (at different depths, grain sizes, locations, etc.); FLY-ASH (from couple of sources nearby Mumbai City); TOPSOILS and OTHER MATERIALS (such as water, cement, lime, gypsum, other admixtures, etc.).

(2) For the bricks manufacturing, all the ingredients were selectively mixed by using different options, and burned and baked in an open furnace at required temperatures as per standard practices and for the required durations.

(3) For the paver's making, all the ingredients were than selectively and mechanically mixed by using different options, and then were formed under pressure mechanisms.

(4) The raw materials and finished bricks / pavers were evaluated for the following:

(a)The physical appearance (such as color, smell, etc.),

(b)The integrity (brittleness, etc.),

(c)The weight, texture, and visual strength,

(d)The laboratory analysis for moisture content, chemicals and minerals, compressive strength, density, failure load, durability, etc.

(C) The Recommendations and the Future Study:

(1) The results are very encouraging to consequently start the next phase of study.

(2) The materials i.e. bricks, pavers, etc. were generally of commercial grade for the required strength and seems to be not objectionable.

(3) The color and texture of some of the brick batches were questionable for the reasons beyond the expertise of the research team. This will need further study.

(4) The quantity and type of fly ash used from the different sources had conflicting characteristics. This will need further study.

(5) The fly ash and construction / building debris used with MSW has a great potential for reducing the existing solid waste problems of the City / State.

(6) The manufacturing process with proper machinery can modify the outcome of the finished materials, probably for the good.

However, that will have to confirm during the conclusive phase.

(7) The leach ability of the heavy metals that may be present in MSW can be a potentially threatening issue and will require an elaborate review.

(8) The process of burning of bricks in open furnaces with MSW can be a questionable issue and will require better options.

(9) During burning of bricks, if proper segregation of MSW has not been carried out, Dioxins due to plastics can be a serious health hazard and need to be considered for the next phase of study.

(10) Similarly, exhaust gases from the open burnings can create other issues such as SPMs, smoke, smell of garbage burning, etc. and will require an attention in the next phase of study.

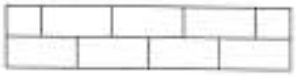
(11) The issue of proper waste segregation practices and educating the work force will require a special attention at the time of commercial venturing of the project.

(12) The major thrust will have to be given to the policy-making of the local authorities in handling of such type of wastes, formulating tax incentives for using such construction / building materials, selection of land for a typical commercial venture, provision of supply of uninterrupted MSW and other wastes for the manufacturers at subsidized rates or no cost, etc.

(13) A system of testing and certification will have to created and put in place for the materials prepared from MSW and other wastes such that the end-users will have complete understanding and faith for using an environmentally sound product. A detailed study and evaluations will require for the same.

(14) The material should be acceptable as a recycled or reusable product. An understanding and educating of all the concerned (from collection of wastes to using the finished bricks or pavers by the end users) will be essential. The next phase of research can focus on these issues and formulate a strategy for the same.

(15) For the end-users such as manufacturers, builders, contractors, etc. giving taxation and other incentives for promoting the use of the recycled and reused construction / building materials may be considered and the same can be also included in the next phase of research study with other issues.



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- Miss Uma Adusumilli, *Chief Planning Division, MMRDA.*
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- Shri Gundekar, *Jr. Overseer, DDG, MCGM.*
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- Shri Niranjan Hiranandani, *Ex. Chairman, Indian Merchants Chamber, Mumbai.*
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- Shri Leo Fonseka, *President, Marble, UN-Habitat Consultant.*
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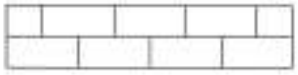
- Shri Subhash Patil, *ALM Office.*
- Shri Vivek Pandit, *Vidhayak Sansad.*

- Shri. Rohan Kalme, *Mechanical Engineer,*
- Mr.Malcome Lobo, *Brick Manufacturer.*
- Shri Kishor Vaidya, *Brick Manufacturer.*
- Shri Shelke, *Brick Manufacturer.*
- Shri. Balkrishana Patil, *Brick Manufacturer,* Thane
- Shri. Mayekar, Civil Contractor, Navi Mumbai.
- Shri. Sultan, Social Worker, Navi Mumbai.
- Google earth.
- And many others.



BIO-DATA

- Mr. Govardhan B Chaudhari - B.E. (Civil), M. Tech. (Soils), having 31 years teaching experience in V.J.T.I. Structural Engineering Department. Consultancy for field and laboratory Soil testing and soil investigations for various types of structures.
  He has developed innovative concepts for
  - Improvement of bearing capacity of weak, soft soil using wedge shear elements layers.
  - Behavior of expansive soils, expansive pressure profiles and design of under reamed and shaft piles and footings placed in expansive soils considering expansive pressure and expansive pressure profile.
  - Mass movement concept for design of large size diameter liquid storage tanks placed on compacted soil embankment.
  - Concept of un-disturbed and disturbed drilled concrete cores and concept of determination of compressive strength of un-disturbed concrete cores.
  - New method of determination of modules of elasticity of concrete cores / rock cores, using platten method.
  - Concept of durable- long life rigid flexible roads for heavy vehicular traffic for container yard pavements at J.N.P.T., Navi Mumbai, which is functioning satisfactorily till this date.
- Mr. Ajitkumar Jain - IAS Officer, 1982 batch, worked at various levels such as Collector, Excise Commissioner and Addl. Municipal Commissioner at Mumbai Municipal Corporation. During his tenure as Addl. Municipal Commissioner in Mumbai Municipal Corporation he was instrumental in involving citizens' participation in Solid Waste Management through the concept of Advance Locality Management. As the Sr. Adviser, Solid Waste Management Cell, All India Institute of Local Self Government piloted the preparation of Action Plan of the State of Maharashtra for implementing MSW Rules 2000. Currently he is working as project Manager for Mumbai Transformation Support Unit, where he is involved in the preparation of Business Plan for transforming Mumbai in to a World Class City.
- Mr. Shantaram S. Shinde - BE (Civil), LLB, MIS, MIE. Passed BE (Civil) from V.J.T.I. in 1982. Worked with Department of Atomic Energy Government of India at Trombay, Mumbai in various capacities from November 1982 to August 1995, finally as Scientific

Officer/Engineer SE. From August 1995 till date working with Municipal Corporation of Greater Mumbai and presently as Deputy Municipal Commissioner (Education). During the service in Municipal Corporation of Greater Mumbai had an opportunity to visit Israel and Philippines for training and convention.

- Dr. Prashant P Bhave - B. E. Civil, M. E. (Environmental Engineering), Ph. D. (Chemical Engineering). Working as a faculty with Civil & Environmental Engineering Department of V.J.T.I., Mumbai for last 21 years.

- Working on various industry sponsored consultancy project related to air, water, noise and solid waste related environmental pollution problems.
- Published research papers in national & international research journals.
- Working as a editorial board member "Journal of Indian Water Works Association".
- Working as a guide for post graduate and under graduate environmental engineering students.

- Dr. Mohan G. Karmarkar - M.Sc., Ph.D (Microbiology)

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  Post graduate guide for M. Sc., Ph. D. scholars.

  Published research papers in national and international journals.

  Completed International Collaborative Research Project with Prof. Cleary, University of Minnesota, US, on Immune response to SCP in Indian subjects with health and disease. (2005)

  PI of ICMR Project on "Rheumatic fever / Rhematic Heart Disease Registry in Mumbai". (2007)

- Mr. A. Y. Mukadam - B. E. Civil, worked in Mumbai Municipal Corporation and retired as Executive Engineer.

- Mr. Pramod N. Kalme - Civil Engineer, worked in various department of Mumbai Municipal Corporation such as Road planning and Construction department, Storm Water Drain planning

and Construction department, Development Plan department and Distribution and Planning wing of Hydraulic department of Mumbai Municipal Corporation. He also worked honorary with various NGO's who are working with the issues of Solid Waste, Health and Education.

- Mr. Kishor Vaidya - Resident of Gaurapur, Tal. Wada, Dist. Thane, Social Activist by nature. His wife is Sarapanch of Village. Conventionally, working in brick kiln and farming. Extremely well experienced in making bricks, particularly arranging kiln, burning kiln, etc... He also has his own brick kiln's and carries out this business from number of years. He actively participated since inception till completion of this research project work.