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APPLICATION OF FERROCEMENT TO RURAL SANITATION

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ABSTRACT

Engineering is process of utilization of technology for the society. Civil engineering is field which is used to built roads, bridges, dams, canals, building, etc and also used for maintenance. However civil engineering plays vital role in developing infrastructure.

In this project it is used for "Application of ferrocement technique to the Rural Sanitation".

The cost of construction is rising day by day due to increasing cost of basic building materials such as steel, sand, cement, brick, timber and labour. The cost of construction using conventional building materials and construction techniques are not economical particularly for low income groups of population as well as middle income groups. Therefore there is a need to develop a cost effective construction technique either by up-gradation conventional technique or by applying new technique. This ferrocement panels are very easy to cast, cure and then manually erect on site. The strength and rigidity are developed through this roofing system and it is cost effective. Hence it is ideally suited for prefabricated construction particularly for the people living in rural areas.

Keywords: *Ferrocement,Chicken mesh,Open mould system.*

I.INTRODUCTION

Ferrocement is a thin composite made with a cement based mortar matrix reinforced with closely spaced layers of relatively small diameter wire mesh. Over the years, applications involving Ferrocement have increased due to its properties such as strength, toughness, water tightness, lightness, ductility and environmental stability. Ferrocement may be cast in various shapes and forms even without the use of form work and are aesthetically very appealing. The success of Ferrocement has been attributed to the ready availability of its component materials, the low level technology needed for its construction and relatively low cost of final products [1] .Due to their thinness, ferrocement elements can be used as roofing / flooring elements to cover large spans. The slenderness of these elements may adversely affect their performance under working loads. Hence, there is a need to study their (a) first crack strength, M_{cr} and (b) load-deflection (P-) behaviour. While (a) and (b) characterize the serviceability behaviour of ferrocement elements, it is equally important to predict their flexural strength M_u one of the ultimate limit states. A number of investigations are available for the flexural analysis and design of ferrocement members. However ferrocement elements do form cracks under certain loads much smaller than the ultimate load and have a durability problem when unmodified cement mortar is used [2]. Durability of a structure is its resistance to weathering action, abrasion, chemical attack, cracking or any other process of destruction [3]. Corrosion of reinforcement is one of the major reasons for deterioration of ferrocement. The corrosion of reinforcement mainly depends upon the permeability of the cement mortar. So by proper selection of chemical and mineral additives, water cement ratio of ferrocement mortar can be reduced. This in turn reduces the pore size, there by achieving very high strength levels and durability [4] and the flexural moment capacity of ferrocement elements increases with the volume fraction of reinforcement [5] . Therefore the authors have conducted this investigation to improve the flexural behavior and durability of ferrocement using modified mortar matrices. The objective of this investigation is to determine experimentally the corrosion performance of reinforcement in ferrocement beams subjected to an impressed current and a high salinity solution. This paper deals with the study of the ultimate strength of precast ferrocement roofing / flooring elements. In the present study trough shaped ferrocement elements and prototype roofing elements were cast and tested. The specimens were tested under symmetric four point loading. Deflection, crack width and ultimate loads were measured and they were compared with the analytical results.

Experimental Work:

Materials Used:

The materials used for the experimental work are as follows:

Cement : ordinary Portland cement (43 grade),

Sand : river sand of fineness modulus 2.56

Reinforcement : chicken mesh with wire woven hexagonal openings of 12mm and

weld mesh of rectangular gird opening of size 76.2 x 25.4 mm

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Chemical admixture : polymer (SBR Latex)
Mineral admixture : fly ash
Cement sand ratio : 1:1

Water cement ratio : 0.321 in 3 women faces troubles in accessing safe toilet facilities.

Present scenario of Sanitation system in India

Safe drinking water, sanitation & hygiene are important ingredient for healthy & good standard of life for every human being. 88 % of all disease is caused by unsafe drinking water, poor sanitation & poor hygiene across the globe. Currently, 2.5 billion people in world i.e. 40 % of world population defecate in open due to lack of adequate facilities for sanitation, and India account almost 638 million. As its consequences, it affects their health as well as the environment. It is found that sanitation & hygiene remains inaccessible to community in spite of several program & schemes of Government of India. So, Creating sanitation infrastructure and public services that work for everyone, including poor people, and that keep waste out of the environment is a major challenge.

School is place which not only provides education to children but also learning environment. After stepping out from house, it plays crucial role in development of a child. It includes cognitive as well as creative development of child. School should look as place which provide environment to learn & bring positive changes in behaviour of children .Though provision of safe water, sanitation & hygiene facilities in schools lead towards healthy physical learning environment. But, only providing facilities do not produce desired result. It also comprises sanitation & hygiene behaviours of people which affect largely. Around 1.5 million, child dies of diarrhoea all over the world each year. Chronic diarrhoea severely affects their development related to mind, body, and immune system.

II.PROJECT OBJECTIVES

To make sure that everyone have a toilet because even in a 21st century about 1.1 billion people in the world (live in 10 countries) who have no toilet and India account almost 638 million.

The main objective of the project is to disseminate, promote and extend safe, healthy and durable sanitation technologies which will improve living conditions of the rural masses and enhance the skills of local construction workers through mass awareness programmes, training programmes, on-site demonstrations and entrepreneurship development in rural society in the production of building materials and use of appropriate sanitation technologies.

The Project activities mainly focus on 3A's AS -

Awareness:

To organize programmes aiming to create awareness on appropriate rural sanitary block among the masses of the rural. Seminars and using mass communication media like Newspapers.

Acceptance:

To build confidence of the rural masses, artisans and field engineers through live demonstrations of newer technologies and promoting on site construction of model demo housing using new materials and construction technologies.

Application:

To mobilize and support for application and use of appropriate R&D and technologies in public which may help in creating visible impact among masses of the surrounding area.

These were further aimed to -

- Develop trained and skilled manpower and artisans locally and enhance productivity and employment potential of construction workers and construction sector.
- Promote and motivate Govt & development organizations and user beneficiaries for mass scale commercial.

Need of sanitation

Women and children are the most susceptible section of the society due to poor sanitation. In our tradition, women have to go in the open to defecate where they are vulnerable to various infections and diseases and in turn this pose threat to other women, men and children. Children are often caught by diarrhoea and insects carry harmful diseases with them. So, unfortunately they become victim and carrier of the disease. Women going in open are forced to stand up when someone passes by. They always have to go either before sun rise or after sunset. However this will be unfair to say that only women and children carry the contaminants or diseases but men are likewise contributing to same by in-hygienic practises. For example, besides open defecation they eat and drink and play with their children without proper hand wash after activities like ploughing their fields. People lose their money for medical treatments. Children's education also suffers.

Government initiatives

Government of India has been running many schemes since last many years. Let us analyse these schemes.

Central rural sanitation programme (crsp)

Central Rural Sanitation Programme (CRSP) was launched in 1986 with the objective of improving the quality of life of the rural people and also to provide privacy and dignity to women by providing proper sanitation facilities in rural areas.

Nirmal Bharat Abhiyan and Total Sanitation Campaign

The concept of sanitation was further expanded to include personal hygiene, home sanitation, safe water,

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Impact Factor- 3.155

garbage and excreta disposal and waste water disposal with the name "Total Sanitation Campaign" (TSC) with effect from 1999. Individual toilets, community sanitation complexes, institutional toilets and solid and liquid waste water systems are constructed under the scheme. The key feature of this scheme is role of CSOs, Community Based Organisations (CBOs) and Panchayati Raj Institutions (PRIs) is very important. It has been recently allowed that certain component of the toilet construction can be taken from Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA) with a maximum ceiling of 4500 Rupees per unit only. Whereas Rupees 3200 Rupees comes from central Government and 900 Rupees is beneficiary's share. States usually give amount of approximately half of the amount provided by central Government. This is sufficient only to build basic structure (substructure) of individual two pit pour flush toilet.

Nirmal Gram Puraskar

To add motivation to this scheme, GOI launched an award based Incentive Scheme for fully sanitized and open defecation free Gram Panchayats, Blocks, Districts and States called "Nirmal Gram Puraskar" (NGP) in October 2003. Till the date many villages have been awarded to bring in motivation among the people specially PRI functionaries at village level to make NBA a success.

Ferrocement in general

Ferrocement is a form of reinforced concrete that differs from conventional reinforced or prestressed concrete primarily by the manner in which the reinforcing elements are dispersed and arranged. It consists of closely spaced, multiple layers of mesh or fine rods completely embedded in cement mortar. A composite material is formed that behaves differently from conventional reinforced concrete in strength, deformation, and potential applications, and thus is classified as a separate and distinct material. It can be formed into thin panels or sections, mostly less than 1 in. (25 mm) thick, with only a thin mortar cover over the outermost layers of reinforcement. Unlike conventional concrete, ferrocement reinforcement can be assembled into its final desired shape and the mortar can be plastered directly in place without the use of a form. The term ferrocement implies the combination of a ferrous reinforcement embedded in a cementitious matrix. Yet there are characteristics of ferrocement that can be achieved with reinforcement other than steel meshes or rods. For instance, the ancient and universal method of building huts by using reeds to reinforce dried mud (wattle and daub) could be considered a forerunner of ferrocement. The use of non-metallic mesh is being explored at several universities. Such meshes include woven alkali resistant glass, organic woven fabrics such as polypropylene, and organic natural fabrics made with jute, burlap, or bamboo fibres. Therefore, the term ferrocement currently implies the use of other than steel material as reinforcement. The following definition was adopted by the Committee: "Ferrocement is a type of thin wall reinforced concrete commonly constructed of hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small size wire mesh. The mesh may be made of metallic or other suitable materials."

III.GENERAL MATERIAL & METHODOLOGY

The material used in ferrocement consists primarily of mortar made with Portland cement, water and aggregate and the reinforcing mesh.

Cement

The cement shall comply with ASTM C150-85a, ASTM C595-85, or an equivalent standard. The cement shall be fresh, of uniform consistency, and free of lumps and foreign matter. It shall be stored under dry conditions for as short a duration as possible. The choice of a particular cement shall depend on the service conditions. Service conditions can be classified as electrochemically passive or active. Land based structures such as ferrocement silos, bins, and water tanks can be considered as passive structures, except when in contact with sulphate bearing soils, in which case the use of sulphate resistant cement, such as ASTM Type II or Type V, may be necessary. Blended hydraulic cement conforming to ASTM C595-85 Type 1 (PM), IS, 1 (SM), IS-A, IP, or IP-A can also be used. Mineral admixtures, such as fly ash, silica fumes, or blast furnace slag, may be used to maintain a high volume fraction of fine filler material. When used, mineral admixtures shall comply with ASTM C618-85 and C989-85a. In addition to the possible improvement of flow ability, these materials also benefit long term strength gain, lower mortar permeability, and in some cases improved resistance to sulphates and chlorides.

Aggregates

Aggregate used in ferrocement shall be normal weight fine aggregate (sand). It shall comply with ASTM C33-86 requirements (for fine aggregate) or an equivalent standard. It shall be clean, inert, free of organic matter and deleterious substances, and relatively free of silt and clay. The grading of fine aggregate shall be in accordance with the guidelines of Table No 3.1 However, the maximum particle size shall be controlled by construction constraints such as mesh size and distance between layers. A maximum particle size passing sieve No. 16 (1.18 mm) may be considered appropriate in most applications. The sand shall be

ISSN 2348 – 8034
Impact Factor- 3.155

uniformly graded unless trial testing of mortar workability permits the use of a gap graded sand. Aggregates that react with the alkalis in cement shall be avoided. When aggregates may be reactive, they shall be tested in accordance with ASTM C227-81. If proven reactive, the use of a pozzolona to suppress the reactivity shall be considered and evaluated in accordance with ASTM C441-81.

Table1:Guidelines for Grading of Sand

Sieve Size U.S. Standard Square Mesh	**Percent passing by weight**
No. 8 (2.36 mm)	80-100
No. 16 (1.18 mm)	50-85
No. 30 (0.60 mm)	25-60
No. 50 (0.30 mm)	10-30
No. 100 (0.15 mm)	2-10

Water

The mixing water shall be fresh, clean, and potable. The water shall be relatively free from organic matter, silt, oil, sugar, chloride, and acidic material. It shall have a pH ≥ 7 to minimize the reduction in pH of the mortar slurry. Salt water is not acceptable, but chlorinated drinking water can be used.

Admixtures

Conventional and high range water reducing admixtures (super plasticizers) shall conform to ASTM C494-86. Water reducing admixtures may be used to achieve an increase in sand content for the same design strength or a decrease in water content for the same workability. Decreases in water content result in lower shrinkage and less surface crazing. Retarders may be used in large time consuming plastering projects, especially in hot weather conditions. If water tightness is important, such as in water or liquid retaining structures, special precautions shall be taken. To achieve water tightness, the water cement ratio shall preferably be kept below 0.4, crack widths limited and, if necessary, waterproofing coatings applied. Mineral admixtures such as fly ash (ASTM C618-85) can be added to the cement to increase workability and durability. Normally, 15 per cent of the cement can be replaced with mineral admixtures without appreciably reducing the strength. Pozzolonic admixtures may be added to replace part of the fine aggregates to improve plasticity. The tendency for some natural pozzolonas to absorb water and thus adversely affect hydration of the cement phase shall be checked by measuring the water of absorption. A quality matrix can be obtained without using any admixtures if experience has shown its applicability. Admixtures not covered in ASTM standards shall not be used.

Mix Proportioning

The ranges of mix proportions for common ferrocement applications shall be sand cement ratio by weight, 1.5 to 2.5, and water cement ratio by weight, 0.35 to 0.5. The higher the sand content, the higher the required water content to maintain the same workability. Fineness modulus of the sand, water cement ratio, and sand cement ratio shall be determined from trial batches to ensure a mix that can infiltrate (encapsulate) the mesh and develop a strong and dense matrix. The moisture content of the aggregate shall be considered in the calculation of required water. Quantities of materials shall preferably be determined by weight. The mix shall be as stiff as possible, provided it does not prevent full penetration of the mesh. Normally the slump of fresh mortar shall not exceed 50 mm. For most applications, the 28 day compressive strength of 75 by 150 mm moist cured cylinders shall not be less than 35 N/mm2.

Reinforcement

The reinforcement shall be clean and free from deleterious materials such as dust, loose rust, coating of paint, oil, or similar substances. Wire mesh with closely spaced wires is the most commonly used reinforcement in ferrocement. Expanded metal, welded wire fabric, wires or rods, prestressing tendons, and discontinuous fibres may also be used in special applications or for reasons of performance or economy.

Wire Mesh

Reinforcing meshes for use in ferrocement shall be evaluated for their susceptibility to take and hold shape as well as for their strength performance in the composite system.

Welded Wire Fabric

Welded wire fabric may be used in combination with wire mesh to minimize the cost of reinforcement. The fabric shall conform to ASTM A496-85 and A497-86. The minimum yield strength of the wire measured at a strain of 0.035 shall be 410 N/mm2. Welded wire fabric normally contains larger diameter wires (2 mm or more) spaced at 25 mm or more.

Expanded Metal Mesh Reinforcement

Expanded mesh reinforcement (metal lath), formed by slitting thin gauge steel sheets and expanding them in a direction perpendicular to the slits, may be used in ferrocement. Punched or otherwise perforated sheet products may also be used. Expanded mesh is suitable for tanks if proper construction procedures are adopted.

Bars, Wires and Prestressing Strands

Reinforcing bars and prestressing wires or strands may be used in combination with wire meshes in relatively thick ferrocement elements or in the ribs of

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Impact Factor- 3.155

ribbed or T-shaped elements. Reinforcing bars shall conform to ASTM A615-86, A616-86 or A617-84. Reinforcing bars shall be steel with a minimum yield strength of 410 N/mm2 and a tensile strength of about 615 N/mm2. Prestressing wires and strands, whether prestressed or not shall conform to ASTM A421-80 and A416-86, respectively.

Discontinuous Fibres and Non-metallic Reinforcement

Fibre reinforcement consisting of irregularly arranged continuous filaments of synthetic or natural organic fibres such as jute and bamboo may be used in ferrocement. If organic materials are used, care shall be taken to conduct appropriate investigations to ensure the strength and durability of the finished ferrocement product.

Definitions

Armature: The total reinforcement system or skeletal reinforcement and mesh for a ferrocement element.
Longitudinal direction: The roll direction (longer direction) of the mesh as produced in plant Skeletal reinforcement: A planar framework or widely spaced tied steel bars that provides shape and support for layers of mesh or fabric attached to either side.
Spritzing: Spraying or squirting a mortar onto a surface.
Transverse direction: Direction of mesh normal to its longitudinal direction; also width direction of mesh as produced in plant

Properties

- Light in weight.
- High modulus of rupture.
- Better resistance to punching shear.
- Non corrosive nature.
- Less crack width as compared to conventional concrete.
- Mouldability properties.

IV.MIX DESIGN

Test of Cement

Standard consistency of Cement.
Date 15/12/2014
Brand-ULTRATECH OPC53

Table2:consistency of cement

Sr. No	Description	Weight of cement (gm)	Weight of water added (gm)	Penetration measured from bottom (mm)
1	Sample 1	400	115	5
2	Sample 2	400	125	4
3	Sample 3	400	110	6

The percentage of water required to produce a paste of standard of consistency is 29.16%

Initial and final setting time of Cement.
Date 15/12/2014
Brand- ULTRATECH OPC53

Table 3:Initial and final setting time.

Sr. No	Description	Initial setting Time (min)	Final setting Time (min)
1	Sample 1	125	375
2	Sample 2	115	350
3	Sample 3	110	390
		117	**372**

Soundness of given sample of cement by Le-chaterliers apparatus
Date 16/12/2014
Brand- ULTRATECH OPC53

Table4.Soundeness test

Sr. No	Description	D1in mm	D2 in mm	(D2-D1) in mm
1	Sample 1	8	8.5	0.5
2	Sample 2	6.5	7.5	1.0
3	Sample 3	6.5	7.2	0.7
			Average	0.73

Compressive strength cement
Date 16/12/2014
Brand- ULTRATECH OPC53

Table5. compressive strength test

Sr. No	Sample	Compressive Strength in Mpa		
		3 days	7 days	28days
1	Sample 1	36.05	46.30	62.33
2	Sample 2	39.35	48.10	64.52
3	Sample 3	38.80	47.40	63.20
	Average	**38.06**	**47.26**	**63.35**

Test of Fine Aggregate
Moisture content in fine aggregate
Date 22/12/2014
Source-River Pravara

ISSN 2348 – 8034
Impact Factor- 3.155

Table6. Moisture content

Sr. No	W1 (g)	W2 (g)	% Moisture content	Avg. % Moisture content
1	1000	992	0.8	0.77
2	1000	991	0.9	
3	1000	994	0.6	

W1= Mass the sand before oven drying
W2= Mass the sand after oven drying
Fineness modulus of fine aggregate by dry sieving.
Date 03/11/2010
Source-River Pravara

Table7. Sieve analysis

Sieve Size in (mm)	Sr. No	Mass retained in (gm)	% of mass retained	Cum % of mass retained	Cum % of mass Passing
4.75	1	0	00	0	100
2.36	2	220	22	22	78
1.18	3	260	26	48	52
0.6	4	150	15	63	37
0.3	5	150	15	78	22
0.15	6	170	17	95	05
Receiver	7	50	05	100	00
		1000		306	294

Fineness modulus = (Total cumulative % of mass retained)/100

= 306/100 = 3.06

Design data:

1. Steel bar of 8 mm dia.
2. cement : mortar = 1:3
3. water : cement = 0.45
4. Thick. of panel = 2.54 cm
5. Chicken mesh = 19 gauge
6. Cover to the panel = 10 mm
7. Curing period = 28 days.

General construction methods

All methods shall have high level quality control criteria to achieve the complete encapsulation of several layers of reinforcing mesh by a well compacted mortar or concrete matrix with a minimum of entrapped air. The most appropriate fabrication technique shall be decided on the basis of the nature of the particular ferrocement application, the availability of mixing, handling, and placing machinery, and the skill and cost of available labour. Several recommended construction methods are outlined in the following subsections.

An integral mould is first constructed by application of mortar from one or two sides onto a semi-rigid framework made with a minimum number of mesh layers. This forms, after mortar setting, a rigid but low quality ferrocement mould onto which further layer of reinforcing mesh and mortar shall be applied on both sides. Alternatively, the integral mould may be formed using rigid insulation materials, such as polystyrene or polyurethane, as the core.

Open -mould System:

In the open-mould system, mortar is applied from one side through layers of mesh or mesh and rods attached to an open mould made of a lattice of wood strips. The form, shown in Fig No.3.5 is coated with a release agent or entirely covered with polyethylene sheeting (thereby forming a closed but non-rigid and transparent mould) to facilitate mould removal and to permit observation and/or repair during the mortar application process. This system is similar to the closed-mould system in which the mortar is applied from one side, at least until the mould can be removed. It enables at least part of the underside of the mould to be viewed and repaired, where necessary, to ensure complete and thorough impregnation of the mesh.

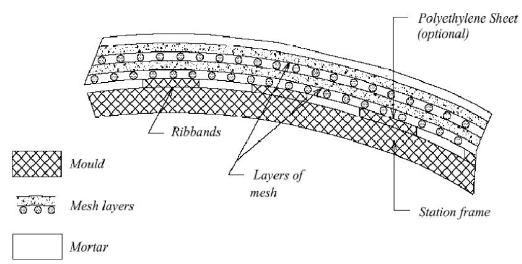

Figure 1: Open-mould System

V.DAMAGE REPAIR

Ferrocement shows cracks when damaged. The cracks often affect the structural action or the durability of ferrocement significantly. Some common types of damage that occur in ferrocement are delaminations, spalls, scaling, fire damage and local fractures. Delaminations occur when ferrocement splits between layers. A spall is a depression resulting when a fragment is detached from a larger mass by a blow, by the action of weather, by pressure, or by expansion within the mass. Scaling is a local flaking of material near the surface of the mortar. Fire damage releases the amount of chemically bound water in the cement, destroys the bond between the cement and the aggregate, and oxidizes the reinforcement. Local fractures are cracks in which displacement of the section has occurred as a result of impact.

Delaminations :

ISSN 2348 – 8034
Impact Factor- 3.155

Delaminations occur when ferrocement splits between layers in laminated constructions due to springing back or bridging of the mesh during construction. Delamination sometimes occurs at or near the neutral axis under impact or flexure when there are many voids in the interior layers. Such areas give off a hollow sound when tapped with a hammer or stroked with a steel bar.

Spalls:

A spall is defined as a depression resulting when a fragment is detached from a larger mass by a blow, by the action of weather, by pressure, or by expansion within the mass. Spalls shall be considered large when their size exceeds approximately 20 mm in depth or 150 mm in any dimension, and shall be repaired by replastering. Spalls are usually caused by corrosion of steel, which causes an expansive pressure within the ferrocement. Chlorides in the concrete greatly increase the potential for corrosion of the steel. Under such conditions, continued spalling is likely and the repair of local spall areas may even promote the deterioration of the concrete because of the presence of dissimilar materials. An area of steel corrosion and chloride contaminated concrete may be considerably larger than the area of spalled concrete, and the full area of contamination rather than the spall itself shall be broken and replastered.

Fire Damage:

Ferrocement may be more susceptible to fire damage than conventional concrete because of the thin cover. If the fire were intense enough to release the amount of chemically bound water in the cement, destroy the bond between the cement and the aggregate, or oxidize the reinforcement, the surface would be charred and spalled so that the damage could be easily identified. Full scale removal and repair shall then be required.

Cracks and Local Fractures:

Hairline cracks and crazing due to temperature changes or drying shrinkage in the cover coat do not require repair. Continuous wet curing will cause autogenous healing, and a flexible coating will conceal the crack from view. If cracks are caused by continuing overloads or are due to structural settlement and the cause cannot be removed, replacement or a structural overlay shall be required. Cracks due to occasional impact or overload may be repaired. Local fractures are cracks in which displacement of the section has occurred as a result of impact.

Evaluation of Damage

- Evaluation of damage shall take into consideration its extent, cause, and likelihood of the cause still being active. The method of repair shall be dictated by the type of damage, the availability of special equipment and repair materials, and the level of skill of the workers employed. Economic factors may influence the decision as to whether the repair shall be extensive and permanent, or limited in scope in response to an immediate problem.
- Repair materials shall bond to the original structure, resist pollutants in the surrounding soil, water or air, and respond the same way to changes in temperature, moisture, and loads. Removal of deteriorated or chloride contaminated mortar trapped within the reinforcing mesh requires a large amount of hand labour, so it may be economical (and better for long term durability) to reconstruct or replace an entire area using the original structure as a form that can be left in place or removed after the overlaid structure has cured. Complete reconstruction shall be undertaken when chloride contamination, mesh corrosion, and deterioration of the mortar are extensive.
- Testing for damage in ferrocement may be done by tapping with a hammer to break into any voids under the surface, or by drawing a metal bar over the surface and listening for sounds indicating voids or the presence of deteriorated concrete. A high quality ferrocement should produce a bell like sound and resist moderately severe hammer blows without damage.

Surface Preparation for Repair of Damage

General :

The primary objective is to remove any deteriorated mortar or mortar contaminated with corrosive agents and to provide a surface to which the repair materials can be bonded properly. The rougher the surface, the greater is the area available for bonding.

Removal of Deteriorated Concrete:

As a first step in any repair all disintegrated, unsound, and contaminated mortar shall be removed. Saws and chipping hammers used for conventional concrete shall not be used for ferrocement unless large sections are to be completely removed. Small areas shall be prepared by hand hammering just hard enough to pulverize deteriorated or cracked mortar,

but not to the point of damaging the reinforcing mesh. A pneumatic needle gun may be used for cleaning out broken ferrocement, opening out cracks, and roughening the surface. Particles of sound mortar embedded in the mesh need not be removed provided they are small enough not to interfere with the penetration of new mortar and they will not project from the finished surface.

Reinforcement:

Any loose, scaly corrosion revealed on cleaning out the mortar shall be removed by sandblasting, water jet, air blasting, or vacuum methods. An alternative method for removing rust is to brush naval jelly or spray dilute

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phosphoric acid over the repair area and flush thoroughly. Where the mesh cage has been displaced but is still intact, it may be pushed or jacked back in place and supported securely to withstand the pressure of applying the repair material. Where the reinforcement has been torn, the old mesh shall be laced back to close the opening. When rods supporting the mesh cage are torn they shall be spliced by a 15 diameter overlap of the partner rod or anchored by hooks.

Cleaning:
Loose particles and dust residue from hammering or sandblasting shall be air jetted or vacuum cleaned if epoxy is the repair material. Water jetting may be used if the repair is to be made with hydraulic cement or latex modified mortar. If an air jet is used, the compressor shall be equipped with an oil trap to prevent contamination of the surface. Surface oil or dirt shall be removed by trisodium phosphate or other strong detergents.

Cracks:
Cracks may be cleaned by hammering out the mortar on each side of the crack and replastered with latex mortar. If opening the crack is not feasible, epoxy or MMA injection systems shall be attempted in accordance with the product directions. The crack shall be cleaned first with oil free compressed air, and small (about 2 to 3 mm) drill holes shall be made at the highest and lowest points in the crack. The surface between the holes shall be sealed with strong coatings or a pressure pad. Catalyzed epoxy or MMA shall be injected at the lower hole until it comes out at the upper hole. Where latex cement grout is to be used, the interior of the crack shall be thoroughly saturated with water and allowed to drain.

Repair Materials
Portland Cement and Sand:
Portland cement and Sand which matches that used in the original construction may be used unless the need for the repair arose because of reactive or contaminated sand. Neat Portland or blended cement paste shall be used to fill small cracks, and a mortar with fine sand shall be used to fill larger cracks or voids. Both shall be used in combination with latex for thin patches and overlays. Larger cracks shall be coated with neat cement slurry, and then dry packed with a very low water cement ratio mortar. The addition of latex to Portland cement mortar markedly improves bond to the substrate and the tensile strength of the patch. Of the synthetic latexes, polyvinyl acetate and poly-vinyl iodine are unsuitable for wet environments. Acrylics may be used as admixtures to improve bonding and as curing compounds. Acrylic latex in concentrated form shall be diluted to 10 to 20 per cent solids and then used as the mixing water for the mortar. Latex mortars may be applied to a damp surface, but the patch shall be allowed to dry thoroughly before being immersed in water.
Polymer Mortars:
Non-latex polymer mortars shall require the use of surface dried and, preferably, oven dried sand. The monomers have very low viscosity and so shall be mixed with thickening agents to be placed in any area that cannot be sealed tightly. Epoxy resins that are moisture tolerant may be used on damp surfaces. Care shall be exercised in applying polymers or the promoters and hardeners used with them which are toxic.

Admixture:
Accelerators may be employed where cement alone is the repair material. Since chloride compounds may promote corrosion, non-chloride accelerators shall be preferred for all ferrocement. Emergency repairs of small areas below the waterline with hot plug, which is neat cement moistened to a putty consistency with a concentrated solution of calcium chloride may be permitted. The hot plug may be carried in the hand or in a plastic bag to the site of the leak, pressed into the hole, and held a few minutes until set. Permanent repair shall be accomplished as soon as possible using materials without chlorides.

Repair Procedure
Mixing :
Small quantities of materials required for ferrocement repairs may be hand mixed on flat surface or in a tray using premixed dry ingredients. For large quantities, a plaster or pan mixer rather than a rotating drum type mixer shall be used. For machine mixing water shall be put in first; then the cement, to form slurry; then the pozzolan, if used; and finally, enough sand to bring the mortar to the desired degree of workability. The consistency of the mortar shall be selected according to the nature of the repair. A slurry of cream consistency shall be used first to paint the moistened edges of the repair area, fill cracks or small voids, and thoroughly coat all the interior mesh and rods. After this, more sand shall be added until the mortar is stiff enough to hold its shape when brought out flush with the finished surface. To avoid excessive amounts of entrained air, mortars containing acrylics or epoxies shall not be mixed longer than two minutes. They shall be applied within thirty minutes of mixing.

Full Depth Repair:
When both faces are accessible, a fluid mortar shall be pushed through the mesh cage from one side until an excess appears on the opposite face. This excess shall then be pushed back and finished flush. A vibrating float

or trowel may be used to place and finish a very stiff mortar. Pencil type vibrators shall not be used.

Partial Depth Patches:

The area to be patched shall first be saturated with water, then air blown or blotted free of standing water until only surface-moist. Cement slurry of not more than 0.4 water cement ratio and of paint like consistency shall be brushed over the whole area and into any openings in the mesh. This shall be immediately followed by a heavily sanded mortar of the same water cement ratio, which shall be vibrated or tamped into the patch and finished flush.

Overlays:

The substrate shall be prepared in the manner prescribed in Sec 12.7.5.3 for patches. The old surface shall be thoroughly cleaned or scarified by mechanical means and the repair materials shall match the thermal characteristics of the substrate. Chemical etching shall be followed by mechanical abrasion, unless the surface is flushed with high pressure water jet equipment. For thin overlays, velocity placement such as spritzing or casting by hand, and shotcreting, shall be used.

Shotcrete:

Shotcrete may be used in ferrocement repair when a large area is involved. Small, low cost portable plaster pumps operating on the Moyno progressive cavity principle with a rotor inside a stator tube shall be adequate for both original ferrocement construction and repair. Shotcrete or plastering equipment may be used for large overlays incorporating additional layers of reinforcing mesh by laminating techniques. Existing surfaces shall be scarified or sandblasted, then saturated with water and allowed to damp dry just before the shotcrete or mortar spray is applied. An initial application of cement slurry is not needed with shotcrete but a latex or wet to dry epoxy bonding compound may be used to advantage with repairs made with plastering equipment.

Curing :

All Portland cement patches and overlays shall be thoroughly cured unless latex compounds are used to seal the surface and furnish water for hydration. Curing shall be instituted immediately for thin patches and overlays. Several layers of paper or cloth soaked in water and covered with a plastic sheet that is well secured at the edges may be used on patches. A full plastic film covering overlays may be used but it may produce discoloration where it touches the surface.

VI. FUTURE SCOPE AND APPLICATION

Future scope

This project provide not only cost effective but also environment friendly sanitary block. This sanitary block intentionally provided for the people living in rural areas because in our country about 70% people are living in rural area and main occupation is agriculture out of which many of them belongs to weaker section.

In present era to build the structures which are:

1. cost effective
2. light weight
3. speedy to construct
4. affordable to the lowest income group

To make India really clean there will be a proper implementation of such project to every school, every anganwadi, every house. Following figure shows economic losses per year due to poor sanitation, with the proper implementation of such project we save lacks of crore in every year.

- **Economic losses per year due to poor sanitation[14]**

Loss to individual: Rs 2500
Loss to a family with 4 members: Rs 10,000
Loss to a village with 1000 household: Rs 1 crore
Loss to India: Rs 2,70,000 crores

Application

Whatever the application of ferrocement, the technique involves is simple and cost effective.

Rural application:

ferrocement technology can be a suitable application in rural areas for construction of cattle sheds, silos for storage of food grains, low cost housing, community centres, well lining, gobar gas plant, lavatory block, water storage tank, canal lining, roofs etc.

Silos

Farms and villages in most developing countries have inadequate storage facilities for grain. It has been reported that up to 25 percent of rice is lost to birds, fungi, rodents, and insects in Thailand.93 Ferrocement silos for storing up to 30 tons of grain appear quite suitable and economical for developing countries. Ferrocement offers low permeability and with appropriate sealants can be made airtight. In an airtight ferrocement bin, micro-organisms cannot survive to damage the stored product. Small capacity ferrocement bins (up to 3 metric tons) have been developed, analyzed, and tested in India.95 The units are cylindrical in shape, 3.9 ft (1.20 m) in diameter and are prefabricated in heights of 3 ft (1.0 m). The bins were tested with wheat in a laboratory to ascertain the ability of ferrocement to carry the bin wall load. They were also tested in the field to judge their effectiveness against insects. A cost analysis of ferrocement bins showed them to be less expensive than steel, reinforced concrete, or aluminium bins.**s**

Roofs
In industrially developing countries, there is an urgent need for identifying materials that are economical for building roofs of single family dwellings. It is possible to build walls and floors of a dwelling using local materials. However, past attempts to manufacture (from local materials) roofs which are economical, durable, and resistant to fire, insects, flood, and earthquakes have not been very successful. Large ferrocement roofs have been constructed in Ita

Liqid retaining structure:
Water tank:
It may be a rectangular, circular, spherical, small and large size, open, covered, loft tank, ground service reservoirs, underground and elevated, hopper and shell be. The preceding remarks regarding the need in developing countries for grain storage apply equally to the storage of drinking water. Thus, the use of ferrocement is also being explored in developing countries for water tanks.The International Development Research Centre of Canada, two prototype cylindrical water tanks for the collection of rainwater were designed, constructed, and tested for use in the rural areas of the Philippines In Bangladesh, an elevated ferrocement water tank of 12,500 gal (46 m^3) capacity was successfully constructed in 1989. Ferrocement tanks are an attractive alternative material for the storage of water in the industrially developed countries as well. Small ferrocement tanks of less than 5000 gal capacity (18.3 m^3) are being factory-built in New Zealand.

Effluent treatment plant:
septic tank, clarifier, settling tank, digester, human tank, sludge drying bed.
Gobar:
gas plant, small dams, bandharas, gutters, canal of parabolic section etc.
Soil retaining structure:
Soil retaining wall, counterfort wall, grain silos, face wall panel and anchor plate for reinforced- earth technique.
Building component:
Garages, police chauki, site office, store, wayside shops, latrines, service units, godowns, watchman's cabin, animal shed, bus shelters, telephone booths, cycle stands.
Boats:
Ferrocement boats have been built in almost every country of the world. The People's Republic of China is the only country in which ferrocement boats have been introduced on a large scale. In other countries, ferrocement occupies a fraction of a percent of the total boat-building market. Ferrocement boat construction has been found attractive for many industrially developing countries because:
(a) its basic raw materials are available in most countries;
(b) it can be fabricated into almost any shape and traditional design can be reproduced improved;
(c) it is more durable than most woods and more economical than imported steel;
(d) ferrocement construction skills can be acquired easily;
(e) ferrocement construction is less capital-intensive and more labour-intensive; and
(f) except for sophisticated and highly stressed designs such as those in deep-watervessels, a trained supervisor can achieve the requisite amount of quality control using fairly unskilled labour.
Ferrocement is a relatively heavy material compared to wood and fiber-reinforcedplastic. Most wooden boats below 33 ft (10 m) length are built with a plank thickness of 1 in. (25 mm). To obtain the same hull weight, ferrocement would have to be only 0.3 in. (8 mm) thick. Although small ferrocement boats have been built of this thickness, thecorresponding impact resistance is not sufficient for work boats used in fishing or transport. At its present stage of development, ferrocement has proved most suitable for boats above 33 ft (10 m). Even for this larger size, a ferrocement boat will be heavier than a wooden boat, but this is of little disadvantage at moderate speed (between 6.5 and 10 knots)

VII. CONCLUSION

1. Being a precast product, use of ferrocement panel will increase the speed of construction and also make the construction of buildings feasible in bad weather conditions.
2. At service loads, ferrocement shows a large number of cracks of smaller crack-width compared to few wide cracks in reinforced concrete.
3. The use of ferrocement panel with higher ductility will make the structure less prone to seismic damage.
4. Increase in number of mesh layers also improves the ductile behaviour of ferrocement slabs.
5. Cost reduction, 40% cheaper than conventional techniques.
6. It can be fabricated in any desired shape, hence it is more suitable to special structure like shell

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and structure like roof, silos, water tank and pipeline.

7. As the material required for the construction of such panel is less, it is environment friendly.
8. Less use of cement and steel for any section compared with RCC, with corresponding reduction in self weight.
9. This technique dose not required any scaffolding, shuttering or a concrete mixer or a vibrator.

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REFERENCES

1. *Ferrocement technology a construction manual by- Dr. B. N. Divekar page no. 13,14.*
2. *Journal of the ferrocement related papers compiled for the 2nd National Conventation on Ferrocement.*
3. *IFS Committees 10, 2001 "Ferrocement Model Code" Building Code Recommendations for Ferrocement.*
4. *ACI Publication SP.61, 1979 "Ferrocement– Materials and Applications", pp 1-195.*
5. *549R-97, "State of the Art Report on Ferrocement", Reported by ACI Committee, 1997.*
6. *Joseph-Louis Lambot's., "Ferrocement Applications in Developing Countries," National Academy of Sciences, Vol. 4, No. 89,January 2007.*
7. *"Ferrocement: Applications in Developing Countries," National Academy of Science, Washington, D.C., Feb. 1973, 90 pp.*
8. *IS:12269-1989, Specification for 53 Grade Ordinary Portland Cement, Bureau of Indian Standards, New Delhi, India.*
9. *IS:383-1970, Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standards, New Delhi, India.*
10. *World Health Statistics 2013, by world Health Organization, WHO Press, Geneva, Switzerland.*
11. *Progress on Drinking Water and Sanitation, UNICEF and WHO, 2013 update.*
12. *An overview of status of drinking water and sanitation in schools in India', by UNICEF, 2012.*
13. *'India Open sanitation portal links.http://indiasanitationportal.org/*
14. *(Source: UNICEF 2013) CLRA: Policy Brief for Parliamentarians August-September, 2013. P No.1*
15. *An article published in Daily Sakal dated 19th Nov. 2014*
16. *www.riazhaq.com/2011/10india-leads-world-in-open-deficaton.html?m=1*
17. *(Source : JMP UNICEF- WHO 2013) : Policy Brief for Parliamentarians August-September, 2013. P No.2*
18. *(Source: UNICEF 2012 report) : Policy Brief for Parliamentarians August-September, 2013. P No.2*
19. *Present Scenario in India: Policy Brief for Parliamentarians August-September, 2013. P No.4*
20. *An published in Daily Sakal dated 7th Jan. 2015*
21. *Assumed longitudinal and transverse Direction: Ferrocement structure P No.6-697*
22. *Armature System: Ferrocement structure P No.6-706*
23. *Closed -mould System: Ferrocement structure P No.6-706*
24. *Integral -mould System: Ferrocement structure P No.6-707*
25. *Open -mould System: Ferrocement structure P No.6-707*
26. *Sample of hexagonal and welded wire mesh: State-of-the-Art Report on Ferrocement Reported by ACI Committee 549, P No.7*
27. *Economic losses per year due to poor sanitation: Policy Brief for Parliamentarians August-September, 2013. P No.4*