ADVANCED FERRO CEMENT TECHNOLOGY FOR FLEXIBLE ARCHITECTURE A NEW WAY TOWARDS ACHIEVING RESPONSIVE DESIGN

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Abstract— Ferro cement technology is currently getting regard all over the world. It is a good unusual for having flexible flowing architectural elements in the city fabric. Now a day the world is in a transform phase & leading to a rapid urbanization. Ferro cement technology could be a great stimulator to achieve responsive designs as per the existing context guidelines in the current scenario. It will also help to facilitate the limitless design policies in implementation. This paper analyses the properties of Ferro cement & the components involved in the technology which helps the designers to have structures, facades in any form. It further focuses on the case studies which prove the functionality & workability of the material & technology. This technology could be linked with digital software to get an ease in on site construction & fabrication. This paper also suggests its various applications which could play a major role in sectors like affordable housing. This paper concludes that Ferro cement can be a best suitable technology in upcoming years with a large no. of applications. This study is limited to its architectural applicability & its advantages.

Keywords— Flexible, Responsive, Limitless, context, Architecture

I. INTRODUCTION

A. Advantages of Ferro cement as a material & technology for flexible architecture

The debate of having linear forms or curvilinear dynamic forms inside the city is going for many previous decades. Some architects feel that it is destructive type of architecture. The other side says that it is a future through deconstruction concept to create constructive architecture. Ferro cement as a material & technology contributes to both types of architectural applications. It gives flexibility for the designers to have actual implementation of ideas that they perceive in their minds. It is also a fact that the conventional construction materials are becoming excessively costly day by day. Innovative and low cost construction materials and techniques thereby become urgent need. Ferro cement may serve as one such alternative. Ferro cement is an excellent material which could be used in façade developments & structural development also. It possesses high value of ductility& energy absorbing capacity which gives advantage in wide range of construction scenarios.

The criteria of flexibility are very important to maintain the originality of ideas while implementing it on site. Ferro cement as a material & technology helps the designers to create the flowing non disturbed forms in urban infrastructure.

Ferro cement also facilitates the adaptive type of designs needed to maintain the regional architectural value of that particular region.

Ferro cement is form of reinforced concrete made of wire mesh, sand, water, and cement, which possesses good qualities of strength and serviceability in different type of applications. It can be constructed with a minimum of skilled labor and utilizes readily available materials. This technology is widely used in developing countries also because of raw material availability everywhere.

Fig 1. Ferrocement applications in rural & urban area
Source: Akvo foundation & alamy.com

The skills for ferro cement construction could be acquired at a local level & at urban level also. It could be worked out by using trained skill labor for actual on site laying & mixing of material & non skilled labors for formwork placement.

Shubham et.al (2016) described Ferro cement as 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 which may be made of metallic or other suitable materials. Ferro cement possess certain unique properties such as high tensile strength-to-weight ratio, superior cracking behavior, lightweight, mold ability to any shape and as mentioned earlier i.e. semi skilled local workmanship also.

Ferro cement also involves wide applications like structural members in affordable housing projects, boat building services, construction of water tanks. Even it operates very effective in repairs & rehabilitation works.

B. Responsive design

Today everywhere in the world there are many works are going on in exploring of responsive designs. It may be user responsive design or climate responsive design or anything else. The regions are losing their regional

traditional characters and monotonous characters are getting formed ubiquitously. It is very important to maintain regional

responsive design by achieving needed practices from professionals for this. The developments generally happen with existing guidelines of land profile, geometry, climate, proposed road linkages of the city. The urban infrastructural lines i.e. road, foot paths, squares, circles, gardens must be complemented through communicative facades of the buildings. It could be achieved by the use of ferro cement applications in facades, social public elements like water fountain, statue, sitting places in the urban fabric.

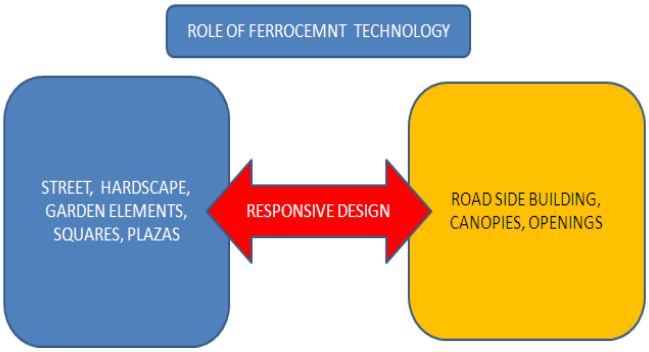

Fig 2: Responsive Design framework through ferro cement
Source: Author

Ferro cement could help in traditional façade developments also. The motifs, sculptures could get developed & could be involved in facades of the cities which possess strong historical background.
Ferro cement application could be done in the cities which are newly developed to establish the administrative or dominant effect into a particular area, square, plaza. This will enhance the beauty of facades & create a guideline for further developments. Conceptually it could be defined as a connecting triad between complementary character, identity of the building & aspirations for that particular area.
Responsive design is only the connection of a user and a building but a comprehensive framework in which every component is an inseparable part of that whole cityscape.

II. REVIEW OF LITERATURE

The literature review of Ferro cement technology & it's applications suggest a wide variety of Ferro cement as a material technology. This technology will definitely ensure the time & cost effective projects leading to the profit of financial institutions & increasing the interest of designers & developers to have a flexible architecture.

Akhtar et al. (2009) studied ferro cement & they suggested ferro cement as an urgent need to explore a building material that is structurally efficient but at the same time, should be friendly, cost effective and especially the ones that can perform the desired functions. He further gave the observations like most dwellings in rural areas are made of cheap local materials including low quality wood (which is easily attacked by termites), scrap metal, thatch and/or earth products (like clay, mud, sand, rock/ stone) which are temporary and unsafe.
Pushyamitra Divekar, (2011) suggested that Ferro cement is such a material that is slim and slender but at the same time strong and elegant.
Abdullah and Takiguchi (2003) studied the ferro cement as a potential solution to roofing problems.
Robles-Austriaco (1992) stated that the Precast ferrocement elements have been used in India, the Philippines, Malaysia, Brazil, Papua New Guinea, Venezuela and the Pacific for roofs, wall panels and fences. Precast corrugated roof units reinforced with local fibers comparable to asbestos cement sheet and galvanized iron sheet are used in Singapore, India, Indonesia, Peru and Zimbabwe.
Paramasivam (2011) stated that highly mechanised techniques have been used to produce water tanks, sunscreens and secondary roofing slabs and cladding materials for facades in ferrocement at Singapore.
This literature review shows the applicability & flexibility of ferro cement technology all over the world. It is previously used in developing countries also therefore could be a great tool to achieve the region sensitive architecture in the respective regions.

III. METHODOLOGY

The methodology used is primary & secondary data collection through extensive literature references. The application area is explored through case studies of ferro cement structures. The analytical findings are based on the observations through the case studies. This research paper is focused to reveal the flexible application values of ferro cement technology to architecture only.

IV: PROPERTIES

General properties of Ferocement:

1. Ferrocement structures are thin and lightweight compared to conventional reinforced concrete. Hence considerable reduction in self weight which reduces foundation cost.
2. These structures show high level of impact and cracking resistance.
3. Ferrocement is more suitable for water retaining structures due to water tightness and impermiability.
4. Partial or complete elemination of formwork is possible. Hence cost saving.
5. Easily maintanable and can also be repaired in case of structural damage without major problems.
6. Fire resistant property gives the occupants time to evacuate.
7. Minimal ecological footprint during construction due to minimizing waste, minimizing machinery used for construction and locally sourced materials.

The unique properties of ferrocement that make it a designer's choice are:

1. Complex shapes ar informal and limitless design is possible due to the fluid fabric nature of ferrocement.
2. Very thin cross sections thus saving space.
3. Thin members allow use of ferrocement in designing inbuilt furniture items.
4. Certain ornamental features such as column capitals, eaves, decorative railings can be manufactured in ferrocement.
5. Most suitable material for landscape elements as landscape designing usually employs use of free forms.

CASE STUDIES & ANALYSIS

V: CASE STUDIES:

1. The Hussain Doshi Gufa, at Ahmedabad:

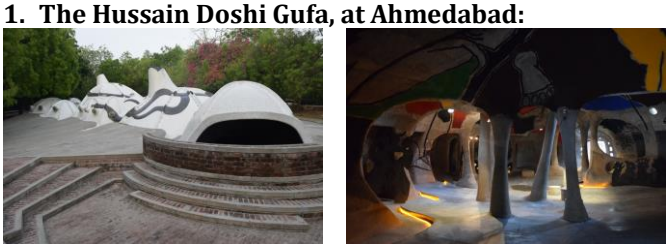

Fig 3: Hussain Doshi Gufa Entrance and interiors
Source: Author

This underground structure in ferrocement is a classic example of Architect's thoughts converted to actual structure**.** The architectural style of "Biotecture' (buildings with organic, freeflowing forms) is used in construction giving free reign to architectural expression. This is an Art gallery which is an underground cave structure with roof of interconnected domes made in ferrocrete. The structure built in 1993 has not only withstood the 2001 earthquake but has also remained crack free till date. The snout like structures were created on the outer surface of the dome to let in natural light and make create everchanging patterns of light throughout the Day. This cave gallery displays Husain's art directly painted on the walls and ceiling. Tis gallery stands as a fine example of thinking out of the Box , beyound RCC and cutting material and labour cost.

2. Sports Palace in Rome:

For twenty years before the Olympics, Pier Luigi Nervi had devised a new building material and a unique construction process. The reason for using ferrocement lay in the then economic condition. Due to the complicated conditions in Italy steel was suddenly rationed. The architects and engineers had to experiment with alternative methods to replace RCC which was then a common material for all scale buildings. Architect Annibale Vitellozzi and Engineer Pier Luigi Nervi designed the building from the standpoint of economy, speed of execution and efficiency in 1956-1957. It is a covered stadium to accommodate 5000 spectators during boxing events and around 4000 for tennis, basketball or gymnastics events. Its circular form with diamete 78m and surface is spherical cap of 69.20m in dia is made of 1620 diamond shaped ferrocement prefabricated sections. The forms supported by 'Y' shaped columns.

Fig 4: Sports Palace, Rome- structure and Ferrocement panels
Source: Author

V. CONCLUSION & SUGGESTIONs

Ferrocement technology has proven to be a boon for the architects to think out of the box. Its adaptive and fluidic nature helps to gain any shape that the design demands. Precast wall and slab units in ferrocement can be effectively used for modular construction. Its modularity enhances the multiplication and becomes a time saving factor that is a major sought out property in these times.

All said and done application of the system needs quite a experience in the field for safe design. Ferrocement can be an alternate material for the conventional RCC as it proves to be economical and designer's preference.

Ferro crete applications offers the flexibility in design stategies which gennerally creates urban fabric. It is useful in rural settlements also. Ferro cement technology is a good tool in achieving responsive design with climate user & all other side aspects.

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