Analysis of Time and Cost in Construction Industry Using Ferro-cement as New Construction Material

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Abstract— Application of Ferro-cement in construction industry is large due to the low self-weight, No need of more skilled labor, no need of formwork. Ferro-cement is generally used repairing, strengthening and retrofitting of the structures. Ferro-cement was firstly developed and used by Italian architecture, P. L. Nervi in 1940.

Different type of meshes is used in Ferro-cement such as, Hexagonal wire mesh, welded wire mesh, Woven wire mesh, expanded metal mesh, and three dimensional meshes. The desired shape may be prepared from a multi-layered construction of chicken wire, and if needed reinforced with steel wire or steel bars.

***Keywords*— Ferro-cement, Metallic mesh, Lightweight structure, Sustainable construction material, Construction Cost and Time.**

I. INTRODUCTION

Ferro-cement is a thin composite made of a fully mortar matrix based on cement, reinforced with thoroughly spaced wire-mesh layers of small diameter. The mesh can be produced from steel or various appropriate materials to generate parts of little thickness, resilience and excessive robustness, and rigidity and high strength will be accomplished once correctly shaped. Ferro-cement is believed to be one of the distinctive techniques of construction that are now used throughout the globe. It is the cement material made of tightly spaced mesh layers in which the reinforcement is provided evenly throughout the material of Ferro-cement making it ductile from fragile. Ferro-cement has a high strength and serviceability that acts as a building material for several purposes. Compared to RCC, it functions as a homogeneous material having comparable characteristics in all directions. The mesh surface area in Ferro-cement is very large, which enables the mortar to properly bond with it, resulting in lesser cracks, exhibiting greater durability because of the same. It also has a much greater tensile strength and rupture module that helps to avoid cracks.

Similar skinny building material offers characteristics that do not match Ferro-cement's characteristics such as strength, toughness, water tightening, lightness, and durability. The bending behaviour of Ferro-cement and concrete reinforced cement yields practically similar results. Ferro concrete is however regarded a hybrid material lies between reinforced concrete and stainless steel.

Ferro-cement also be said a type of thin reinforced concrete consist of small-diameter wire meshes spaced uniformly throughout the cross section instead of placing reinforcing bars and Portland cement mortar is used in place of concrete. Metallic mesh is the most general type of reinforcement. Meshes prepared from alkali-resistant glass fibers, and woven fabric made of vegetable fibers such as jute-burlap and bamboo, have also been tried as reinforcement.

Conventional reinforced concrete is combines of steel bars and concrete. Shuttering and scaffolding are very essential. Ferrocement is a configuration of weld mesh, mild steel angles or bars, chicken mesh and mortar. This mixture becomes an analogous material and can be built in conditions and in any shape. Ferrocement is thin in size that's why lightweight nature but its ductility is very high than conventional RCC. Ferrrocement means 'Strongly bonded cement mortar and surrounded in layers of fine wire meshes making it an alike properties and ductile composite'. [1] According to Naval Ship R&D Center, 'Ferrocement consists several layers of wire mesh reinforcing mortar of sand and Portland cement'. [2] All conventional material can be changed by Ferrocement and material containing steel, timber, cement, clay, wood etc. can be saved to some extent. Production of steel and cement emits huge amount of greenhouse gases (GHGs) and harms the environment. That emission measured in terms of CO2. Generic terms like carbon credit used for any tradable certificate or permit representing the right to release one tone of carbon dioxide or mass of another greenhouse gas with equivalent to one tone of carbon dioxide [3]. Certified emission reductions (CERs) is carbon credit's unit.

Ferrocement is substitute to conventional RCC construction. Ferrocement technology is getting more attention due to its advantages such as light weight, water tightness, ductile, ease in construction and maintenance. Application of Ferrocement started with boats and now, various structures such as building, retaining wall, swimming pools, water tanks, domes, corrugated roof, etc. are being built with it. Reduction in CO2 emission is another important advantage of Ferrocement. For sustainable development and prevention of environment, this feature of ferrocement, makes it more suitable for construction. Due to least research work is done in this context research work carried out for estimation of CO2 emission of ferrocement structure.

From the early history of ferrocement and through its subsequent evolution, the definition of ferrocement has been changing. Ferrocement also be explained as a type of reinforced concrete (RC) in which the small size of the reinforcement, means wire mesh, and the aggregate, means sand. The basic definition of ferrocement is given by ACI committee [1], however before and after this committee report, ferrocement has been defined with different researcher and committee [2–8].

1.2 Durability of Ferrocement

According to the ACI Committee, 'durability' is defined as 'ability to resist weathering action, chemical attack, abrasion, or any other process of degradation ', that is, when concrete exposed to environment durable concrete will retain its serviceability, original form and quality. For ensuring 'durability' different measures required in conventional reinforced concrete which arebased also applicable to ferrocement, since, ferrocement has almost the equivalent type of ingredients/constituents, except, coarse aggregate. However, there are other unique factors susceptibility to corrosion which affect durability are:

- Very small cover to the mesh reinforcement.
- Very low cross-sectional area of the mesh reinforcement wires.
- Because of small wires being used the surface area of the reinforcement is high.
- To prevent corrosion, Mesh reinforcement are galvanized, but the zinc coating can cause and produce hydrogen gas bubbles during hydration.

1.3 Aims and Objectives

- To find the differences in cost by analyzing construction project cost between RCC structure and Ferro-cement structure
- To find How much time need to complete one project using Reinforced concrete and Ferro-cement material
- To minimize energy costs / waste without affecting production & quality and to minimize environmental effects and to identify the source of wastes for specifically chosen activities at a construction site and relate them to the waste generate in construction industry using both materials.
- To study Effect on total project cost and benefits using Ferro-cement material and advance construction techniques.

II. LITERATURE REVIEW

2.1 Kavita V. Desai, Dr. Deepa A. Joshi Review on Ferrocement an effective alternative for construction industry, International journal of innovation in engineering and technology (IJIET) Volume 6 Issue 2, December 2015

In this paper they studied ferrocement is a composition of weld mesh, mild steel angles or bars, chicken mesh and mortar. This can be built in any shape and condition due to homogeneity of mixture. This paper reviews, research work carried out on ferrocement. For constructing building, roads, dams, bridges, etc million cubic meter concrete is being used. For that construction consumption of steel and cement on large scale. The environment gets harm due to huge amount of CO2 emits during production of steel and cement. To save the earth it is important to replace such material. For materials like RCC, bricks, timber, steel etc, ferrocement is best option over convetional concrete. and construction become eco-friendly. Discussion of historical development, advantages of ferrocement and the research work should be done in detail. After studying the available literature, it has been found that the research work on Ferrocrete in context of CO2 emission is required to be carried out. From the above methodology they conclude that ferrocement is an alternative to conventional RCC construction. Advantages such as water tightness, light weight, ductile and ease in construction and maintenance is more attentioned in ferrocement construction. As we noticed ferrocement is started with boat construction and now big structures such as building, retaining wall, swimming pools, water tanks, domes, corrugated roof, etc. Reduction in CO2 emission is another important advantage of ferrocement. Development and Environmental friendliness of ferrocement are featureds due to it is sustainably used. However very less research work is done in this context and hence carried out research work for estimation of CO2 emission of ferrocement structure.

2.2 Lakhan Murari, Elson John, Review on Study on performance of prefabricated ferrocement columns and wall panels, International journal of engineering research and science and technology (IJERST), Special Issue, Vol. 3, No. 1, April 2016

In this paper they studied about performance of fabricated Ferro-cement column and wall panels. 1 m x 1 m is Size of Ferrocement wall pannels with 5 cm and 2.5 cm thickness and 0.20 m x 0.20 m x 1 m and 0.25 m x 0.40 m x 1 m are sizes of Ferrocement Hollow Columns with 0.03 m thickness, load was casted and tested in laboratory and their failure load was studied. Hollow section, pcc used for column and casting done by normal method. In this paper they also include cost comparison, for cost comparison of ferrocement columns and normal RCC column and wall panels, material cost was taken as the common tool for comparison. If we take the total cost including labour cost, form work cost etc into account, the initial cost for prefabricating the ferrocement elements will be higher compared to RCC elements. But in the long run the total cost of prefabricated element will be less than the cast in-situ elements. This is because the same form work and moulds can be used for many times. For comparison wall panels of sizes 1 m x 1 m x 0.05 m and columns of size 0.20 m x 0.20 m x 1 m and 0.25 m x 0.40 m x 1 m were taken. They estimate that RCC wall panel cost is 757.25 Rs. And Ferrocement wall panel cost was 467.65. Based on results obtained from the study, it can be concluded that the prefabricated ferrocement columns and wall panels may be used for the construction of low rise buildings and in RCC comparison ferrocement is cheaper.

2.3 Ganesh A. Choughule, N. N. Morey, Study and Cost Analysis of Ferrocement Panel for Affordable Housing, Journal of Basic and Applied Engineering Research, Volume 3, Issue 10; July-September, 2016

In this Paper they studied affordable housing using ferrocement panel. As they know about the main difference between ferrocement and reinforced concrete is that Instead of larger diameter rods and large size aggregates ferrocement is comparatively thin composite member made up of cement matrix reinforced with wire mesh of small diameter. The ferrocement Thickness generally in ranges from 25 - 50 mm. The use of non - metallic reinforcement and fibres were encourages by latest ACI code. They conclude that as the number of layers of metal mesh increases the flexural strength of Ferrocement panel increases. The no of layers used to study the flexural strength are two, three and four for panels of size (900x300) with thickness 25 mm & three, four, five & six for wall panels of same size with thickness 40 mm were reinforced with expanded metal mesh. Using mix proportion 1:1.70 of

cement mortar panels were casted and water cement ratio maintained 0.38 also 1% by weight of cement Polypropylene Fibrillated Fibers used. UTM machine used to testing of panel, after curing of 28 days by two-point loading system panel are tested. As compared to conventional brickwork cost of ferrocement panel work is half. As we analyze results found that panels higher flexural strength shown by those panel having more no of layers and deflection less compared with panels having less no of layers of mesh also rapid and economical construction of ferrocement structure possible as compared with conventional material for affordable housing.

2.4 A.S.Burakale, P.M.Attarde, Mayuri D.Patil, Ferrocement Construction Technology and its Applications, International Research Journal of Engineering and Technology (IRJET), Volume: 07, Issue: 07, July 2020

In this paper they studied that ferrocement is an innovative material and the ready availability of materials and ease of construction make it suitable in developing countries for housing, and water and food storage structures. For enhancing its performance, repair of RCC structure, material's repair or reshaping ferrocement found to be ideal material. But there is a dirth of research backing and a rationale design should be having to carried out in construction of ferrocement structures as we notice among all field use of ferrocement seen. The performance of ferrocement is mostly depends on wire mesh properties like mesh spacing, dimeter and mesh system's characteristics. In ferrocement construction or combinations of meshes and fibers this review study or experimental research showing new building material are needed. The standard methods of ferrocement construction research upon effect of shape due to which novel forms are generated should be done and benefits brought out. Considering the unique features, the most important structural alternatives for RCC and a repair material is ferrocement no doughtily in the future and thus has a great potential for developing and developed countries alike.

Due to ferrocemnts properties/ advantages it is best alternatives material over RCC and also a construction material. And also recommended that Ferro-cement also use for repair work

2.5 A.S.M. Abdul Awal, M. Siddikur Rahman and M. Bellal Hossain, Development of ferrocement technology for low-cost farm structures, J. Bangladesh Agri. Univ. 2(2): 343-349, 2004

In this paper, unlike other sophisticated engineering constructions, ferrocement requires minimum of skilled labour and utilizes readily available materials. The basic materials needed for ferrocement constructions are wire mesh, sand, cement, water, and mild steel rod as skeletal reinforcement. Structures that have been identified and made in this project are some of many that can be constructed for farm uses using ferrocement technology. The results obtained have demonstrated that utility and economy can both be achieved using very simple techniques utilizing readily available materials. It is expected that the observations made here in this research will bring new concept in gaining wide acceptance of ferrocement for the construction of low-cost but strong and durable structures for farm uses. For the construction of low-cost structures for farm uses ferrocement technology is good option and to familiarize it the present study carried out. Storage structure, cattle trough, irrigation and drainage canal lining, and manhole cover Are the structures that have been identified for farm uses. Using simple techniques utilizing of locally available material, design and fabrication of structure have been made. The cost of construction of Ferro-cement structures has also been estimated on the basis of present cost of materials and labour. In construction of low-cost structures for farm hope that observation made in above study will bring new ideas in achieving wide acceptance of this technology.

III. METHODOLOGY

Research Methodology will be designing a questionnaire survey by which we can find out the factor affecting the construction cost which directly related with material use in construction projects.

3.1.1 Formation of questionnaire

For this particular project, a questionnaire survey approach has been adopted to find the impact of various factors affecting the cost of project. The design philosophy of the questionnaire was based on the fact that it had to be simple, clear and understandable for the respondents and at the same time it should be interpreted well by the researcher.

3.1.2 Through literature survey

It has been seen that a significant amount of research has already been done in perspective of structure. The use of Ferro-cement and their factors affecting the construction sector in India not so much data available for study. And hence, a preliminary research through various literatures throughout the globe led to the formation of a preliminary list consisting of factors affecting the project cost and time.

3.1.3 Through preliminary survey of the sites

After recognizing the basic factors through the literature survey, preliminary survey of various sites led to the understanding the nature and relative importance of those factors in the Indian working conditions. The survey co-related the effectiveness of global factors with respect to the Indian sites and also gave us and practical insight adding a few more factors, though they are area specific.

3.1.4 By talking to local experts

Due to varying environmental, social and economic changes, the effectiveness of the factors may also vary over the period of time, and due to the time constraint of the project, it's not feasible to cover all the aspects. And hence by talking to local experts, who are equipped with the practical knowledge of the situation, information required to verify the importance of a particular factor with respect to Indian working conditions can be achieved.

And hence, the factors affecting the construction cost and time were identified through the literature based on previous research, site survey and with input, revision and modifications by local experts.

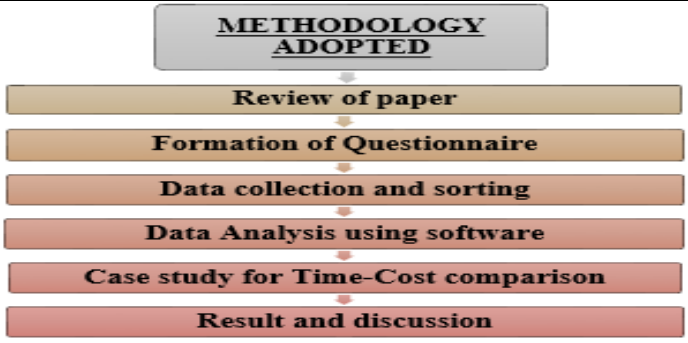

Figure: Methodology chart

IV. FERROCEMENT CONSTRUCTION APPLICATION

As thin structural elements, ferrocement has been used in numerous applications ranging from engineered structures to architectural applications such as sheets, boards, shells, hulls., and constructions where the minimize of self-weight, water permeability improved and very fine crack widths develops are essential at such places sandwich type construction of thin skin used.

4.4.1 Structural Applications

When structural members of different types subjected to different type of stresses ferrocement can be used. As a compression member, hollow columns with horizontal stiffeners can be cast in ferrocement. To increase the strength of columns or walls in concrete, RCC, stone or brickwork it can be encased in ferrocement. Members like shells, domes, pyramids subjected to membrane stresses are very easily casted in ferrocement; and due to homogeneity of material, full section of member is utilized to resist the membrane stresses. A ferrocement hyperbolic paraboloid shell structure was constructed by the student chapter of the American Society of Civil Engineers at Funded by 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. A ferrocement is greatly used in water-retaining constructions and other similar constructions where crack width is a design criterion. Due to superior extensibility and under service load very small crack widths are appeared, ferrocement provides excellent leakage characteristics for applications in water tanks; moreover, it does not fail due to pressure increase, ferrocement stretches and acts as a safety valve.

4.4.2 Roofing Applications

Ferrocement appears to be an economic alternative material for roofing; and flat or corrugated roofing system is quite popular Ferrocement roofing materials can be factory mass-produced in prefabricated form, also can be fabricated in-situ in villages and best suited process to concentrated demands of urban area. Construction of hundreds of ferrocement roofs for poorer areas of Mexico has been well documented; and large ferrocement roofs have also been constructed in Italy spanning with a thickness of 30 mm. In European and South American countries for large roofing span structure with internal ribs ferrocement used successfully. Domes have been constructed in Jordan using thick ferrocement with internal ribs.

4.4.3 Need for Repair of RCC Structures

Cracking and spalling are major reasons for the deterioration of RCC structures (due to incorrectly made construction joints, poor compaction and due to corrosion in the reinforcement bars accelerated by a lack of adequate cover). Due to wrong design of structure and due to poor quality of materials used cracks are developed in structure, and this starts to corrosion; in course of time due to increase in corrosion, peeling of concrete cover or spalling of concrete takes place. Use of proper repairing methods for damaged or deteriorated RCC structures is a necessity not only to serve the intended service life but also assure the safety of buildings value: Ferrocement Repair Techniques A good repair improves the function and performance of structures, restore and increase its strength and stiffness, enhances the appearance of the concrete surface, issues water tightness and prevents access of the aggressive category to the steel surface durability. By using ferrocement repairs and rehabilitation strength of columns, beams and slabs icreased up to 30% as well as prevent crack formation. Other types of repair and strengthening techniques required formwork where ferrocement required no-framework is advantage over all; enhanced crack resistance combined with high toughness, its rapid constructions with no involvement of heavy machinery, it imposes small additional weight, and an economical aspect of rehabilitation considered, this material proves to be a cost effective solution for rehabilitation and general applications. The ferrocement material does not allow the penetration of water and atmospheric gases due to waterproofness of system. It can totally replace deteriorated/ damaged RCC with reduction in dead load.

4.4 Ferrocement Confinement

Around defective RCC columns of any shape ferrocement confinements is done. Confinement carried out to enhance the ductility, strength, and energy absorption capacity of existing columns. Alround the RCC columns 30mm jacketing layer is created with ferrocement to increase its load carrying capacity.

This confinement layer also provides water tightness and prevents ingress of the aggressive species to the surface of original concrete. Ferrocement confinement increases the performance or function of structures that's why appearance of the existing RCC structure enhances. The repair using ferrocement in the structural element can withstand for long years.

V. CONCLUSION

This review paper written to summarized versatility of ferrocement but ferrocement is unharnessed material. It's easy to construct with basic materials makes it suitable for low cost light construction especially in developing countries. The applications of ferrocement in both cast in situ as well as precast construction have been explored in all areas of civil engineering but there is a dearth of enough research and a coded rationale for design. The standardization of procedures and applications as load bearing and non-load bearing elements is lacking. The regulatory authorities take one step forward in generating codes for ferrocement structures. The performance of ferrocement elements greatly depends on material characteristics. This review study included more experimental research with sustainable building materials, combinations of meshes, fibers and fillers. Considering the versatility, economics, simplicity ferrocement can prove to be a potential alternative to RCC.

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