Earthquake Resistant Construction using Ferrocement

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***Abstract*—Earthquake resistant construction can be done by ferrocement. Ferrocement is a versatile material and can be used for constructing hollow slabs, hollow columns and cavity walls. The hollow columns, hollow slabs and cavity walls are to be filled with sand or water. Then the same will exhibit the earthquake resistance. This paper presents the construction procedure and effect on earthquake by hollow slabs ,hollow columns and cavity walls.**

Keywords—Earthquake resistant construction;Ferrocement; Hollow slabs;Hollow columns ;Cavity walls

I. INTRODUCTION

Earthquakes are something beyond human control. They are unpreventable and unpredictable. The one and only solution for survival is that to reduce the impact. The major fraction of life loss is due to the collapse of structures. As civil engineers we have to design and build the earthquake resistant structures.

Ferrocement construction is gaining popularity .It is an innovative material, easily available and easy to handle. In developing countries ferrocement is used for purpose of housing and water-food storage structures. Ferrocement is suitable for repairing or reshaping RCC structural elements thereby increase the performance.The unique features makes ferrocement as an alternative for RCC. It have much importance in a developing country like India.

Ferrocement hallow column, cavity wall, and hollow slabs can be constructed with ferrocement technology.. To overcome the limitations of traditional column walls and slabs, ferrocement cavity walls hollow columns and hollow slabs are the best choice. To minimize the effect of earthquake we can use ferrocement hollow columns and cavity wall in small structures as well as in high rise buildings, making the building safer, fire resistant, economical ,sound and thermally insulated. Fig: 1 shows the inertial force on building during earthquake.

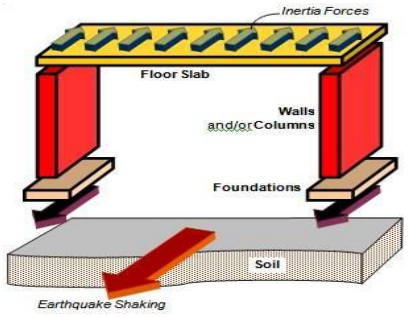

Fig:1 Inertial force on building during earthquake

II. CONSTRUCTION TECHNIQUE WITH FERROCEMENT

American concrete institute committee defines ferrocement as “a type of thin wall reinforced concrete construction” where in usually hydraulic cement is reinforced with layers of continuous and relatively small diameter mesh.

Ferrocement elements undergo high deformations before collapse. It has high level of impact resistance,cracking resistance, toughness ,ductility,reduced thickness ,reduced seilf weight, water-tightness and impermeability,low foundation cost ,low transportation, easily fabricated to desirable size and shape,partial or complete elimination of formwork is possible, simple quick unskilled labour, absence of heavy equipment requirement, economically feasibility and also suitable for both urban and rural areas of developing countries.

A. Ferrocement Hollow Columns

Ferrocement hollow columns is made hollow and have a provision to fill water or sand. As the ferrocement technology is used for the construction of column. Thus the hollow column will have the advantages of ferrocement and the shock absorbing property of sand or water fill. Ferrocement hollow columns increase the earthquake performance, sound and heat insulation and fire resistance of the building. It can be constructed either at site or can be construced as precasted member(fig:2)

Fig:2 Precasted ferrocement hollow column

B. Construction of Ferrocement Hollow Columns

The hollow column consist of the following :-
1. Vertical, horizontal spacer bars
2. Welded mesh around the column
3. Place carboard as support for the external concreting work
4. In addition to the board we can use sand for external support
5. There is opening with end caps at top and bottom to fill and remove the sand before and after completion of hollow column construction
6. Fill the hollow column with sand or water for improving earthquake reistance.

The construction of hollow column consists of following steps:-
1. Column locations are to be determined vertical and horizontal mild steel spacer bars has to be erected.
2. The small thick card boards for packing purposes, support and to prevent drain out is to be erected between inside and outside of the vertical and horizontal spacers..
3. The vertical and horizontal spacer bars are tied with welded meshes around the column.
4. Inside card boards can be tied with the external welded meshes for good support during concreting process action.
5. The hollow portion should be completely filled with sand through one of the opening to provide internal support, for curing and for earthquake resistance.
6. The openings can be made with pipes of larger diameter so filled storing and removal can be done easily.

C. Ferrocement Cavity Walls

Ferrocement cavity wall consists of two wythe's The wall is separated by air space. It is connected by metal ties that are corrosion resistive.. The thickness of external and internal ferrocement wall is in the range 12 mm-25mm thickness of air cavity depend upon the requirement of sound, thermal insulation and earthquake zone. when these ferrocement cavity walls filled with water can absorb earthquake forces.

D. Construction of Ferrocement Cavity Wall

The construction of cavity wall consists of following steps:-
1 The vertical and horizontal mild steel spacer bars are placed during beams and columns construction.
2. The small boards are used for packing purposes. It is used for the same purpose that was explained in ferrocement hollow column construction.
3. Spacers on both sides are tied with welded meshes.
4. . Inside card boards can be tied with the external welded meshes for good support during concreting process action.
5. The hollow portion should be completely filled with sand through one of the opening to provide internal support, for curing and for earthquake resistance.
6. . The openings can be made with pipes of larger diameter so filled storing and removal can be done easily.

E.Construction of Ferrocement Hollow Slab

1.The ferrocement rectangular or circular hollow slab were cast in wooden moulds.The mould has to be oiled before placing the mortar.

2.Cement mortar has to be spreaded evenly within the mould and the first layer of hexagonal wire mesh.

3.The HYSD bars has to be placed along the slab length along with distribution bars.

4.Two more layers of wire meshes were placed on the top of the bars to cover the entire area.

5.Provide one legged stirrups

6.Mortar was spread evenly and compacted to form the lower flange.

In the present investigation it has been found that the prefabricated ferrocement slabs can be used as replacement of one way reinforced concrete slabs for roofs and floors. Deflections of ferrocement hollow slabs are within permissible limits at service load. The deflections are less for ferrocement hollow slabs due to the stiffness offered by the increased thickness and number of ribs. The ultimate load carrying capacity is increased with increase in lever arm in ferrocement hollow slab with the same percentage of longitudinal steel as in the solid slab of reinforced concrete. The decrease in percentage of reinforcement in ferrocement hollow slab leads to decrease in ultimate load carrying capacity than the reinforced concrete slab. A reduction in 18% of self weight in the ferrocement hollow slab and 30% of self weight in the ordinary slab leads to overall economy of the structure by reducing the loads over beams, columns and foundations. The number of ribs, thickness of ribs and the presence of web reinforcement play an important role in developing full moment capacity.

F. Effect of Ferrocement Hollow Columns Hollow Slabs and Cavity Walls on Earthquake

We can constructed ferrocement hollow columns and hollow slabs with stiffeners cavity walls by using known techniques. The ferrocemnet columns having different shape i.e. rectangular, square, circular, hexagonal, etc...., and ferrocement hollow slabs can be made with rectangular or circular cavity similarly ferrocement cavity wall can also be constructed. ferrocement hollow columns , cavity walls and hollow slabs are to be filled with sand during the construction or after the construction. The sand filled in the ferrocement hollow columns, cavity walls and hollow slab will exerts the pressure during earthquake is opposite to the

earthquake forces. Because of this action of opposite pressure by sand on the columns, cavity walls and hollow slabs, earthquake forces will ber balanced automatically reducing the effect of earthquakes. Thus the structures will be more stable.

The reason behind the earthquake resistance is that when the earthquake force acts in one direction the column and cavity walls exerts the pressure due to infill sand in opposite direction of earthquake force leading to auto balance of the structure against earthquake forces.Sand filled inside the hollow column and cavity wall will act as shock absorber.Sand absorb the earthquake forces acting on the structure and make it safe. The ferrocement hollow column , cavity wall and hollow slab are economical as well as it gives better earthquake performance. The ferrocement cavity walls and hollow slab improves thermal insulation. If we use water instead of sand it will absorb the energy .also the horizontal vibration or oscillation of water will be against the inertial force generated by the structures.. The design of earthquake resistant structures must have a low dead load and the center of gravity must be shifted to lower level which is possible by the water tanks made with the above mentioned hollow cavity technique.

IV CONCLUSION

Ferrocement hollow columns slabs and cavity walls provides the facility of water tightness, can be constructed on self-help basis, provides sound and thermal insulation property,and which offers faster construction, economy, reduces the dead load of the structure along with the major matter of concern ie. earthquake performance, save the life of people during earthquakes and improves the earthquake performance of the building. This is a topic having relevance as we are facing the disasters of earthquake , building collapse ,life losses. Further researches can be conducted regarding this topic. Let's have a battle with earthquake to make the theory survival of the fittest to a reality.

ACKNOWLEDGMENT

We gratefully acknowledge Almighty, Christ Knowledge City Engineering College, our guide Er. Shwetha Saju, Er. Reshma Theresa (HOD of Civil Department) and all of them who had helped and inspired to do the piece of work.

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