CHAPTER 7

SUMMARY AND CONCLUSION

7.1 SUMMARY

Nowadays the trends in construction industry have made ‘Modular Housing’ possible at lowest price. It is a type of housing in which major components are assembled in a factory and then shipped to the building site to be joined with each other. This is the simple definition for Modular Housing. In that type of housing, the weight of the element and cost of the element play a major role in construction.

Also in earthquake prone structure, the weight of the elements is one of the important factors that can prevent the loss of precious human lives. In earthquake prone areas, temporary structures are essential and they should be cost effective.

In the case of using steel reinforcement, one cannot control the thickness of the element and it increases the weight of the component. But due to its tensile strength, it provides good yielding and withstands more loads. So an alternate material to reduce the weight, thickness of the component as well as good yields capacity by providing satisfactory strength is very much needed. A consideration of these aspects, lead to the choice of bio-composites.
A bio-composite is a material formed by a matrix (resin) and a reinforcement of natural fibers (usually derived from plants or cellulose). The use of bio-composites is growing well in Aerospace and Automobile industry. But in construction industry, people are scared of using bio-composites.

Based on these concerns, coir is one of the bio-composites which are available abundantly in the locality. So this study is carried out on the slab panel for the purpose of reducing wastage and for choosing modular housing as an alternative.

In this study, for the purpose of comparison, two types of concrete grades, four types of reinforcements (Steel, GFRP, Coir and Coir coated with epoxy), three types of percentage of reinforcement and two types of thickness of slab were taken. The tensile strength of reinforcement is the factor that withstands heavy loads without any sudden collapse of structure.

To assess the durability of natural fibers in concrete is not possible within a limited period. So an accelerated study has been conducted on coir. This study has been mainly carried out to identify the defects and improve the microstructure of natural fibers. SEM and EDS images have been presented and discussed. From the detailed experimental, analytical and theoretical analyses, the following conclusions are made.

Based on the result analysis, it is found that coir and coir coated with epoxy sandwich slabs are the best alternatives for the slab component in modular housing. As per the expectation, the following needs are satisfied:

1. The weight of the element gets reduced.

2. The ultimate load carrying capacity of the slab panel is improved.
3. Tensile strength of the reinforcement (Coir and Coir coated with epoxy) is also good.

4. Improved durability strength has attained because of good bonding with concrete.

5. The SEM and EDC results show that the porous of concrete is filled by the epoxies.

7.2 CONCLUSION

Based on these extensive experimental and analytical investigations, important conclusions have been arrived at as follows:

1. Development of composites using coir fibre is possible. They can be used as reinforcement in concrete slabs. This would result in low cost construction materials with less self weight.

2. In order to use the numerical and analytical investigation, mechanical strength properties of companion specimens are arrived at initially. M20 concrete yields 25.6 N/mm$^2$ compression strength, 2.7 N/mm$^2$ split tensile strength and 25740 Modulus of Elasticity. While M30 is tested, 21 % improvement has been achieved in compression strength, 22.85 % in split tensile and 11.88% in Modulus of Elasticity.

3. From the Flexural test results and corresponding Load-Deflection curve, it is observed that coir rope reinforcement concrete slabs exhibit a reasonable performance when compared with the other reinforced slab. The ultimate load of coir rope reinforcement slab comes around 32.62 kN and epoxy coated coir rope reinforcement slab comes around
35.80 kN. These values are 15.86 % less than RCC and 31.58% lower than GFRP reinforced slabs. Since the percentage of decrement is a reasonable one, the coir rope can be used.

4. The deflection of coir rope reinforcement slab comes around 43.00 mm and epoxy coated coir rope reinforcement slab comes around 42.50 mm. These values are 57.40 % more than RCC and 11.00 % lower than GFRP reinforced slabs. Since the percentage of decrement is a notable one, further investigation is required.

5. In both coir and epoxy coated coir rope reinforced composite slabs, initial cracks are formed at different faces of slab during the initial loading condition. At the ultimate stage, the middle crack widened for a longer time and failed finally. This shows the ductile performance of composite slabs.

6. Durability is one of the major questions in using natural fibres in concrete. To evaluate the performance of coir rope reinforced concrete slabs under different severe environment, acid and sulphate tests are carried out. Visual inspection results indicated that the coir reinforced slabs did not deteriorate much and the ultimate load taken after 90 days of acid and sulphate attack tests are, 11.8 kN and 13.1 kN respectively. This is 6.27% and 5.95% lower than that of the conventional load. So coir and epoxy coated coir has the ability to use reinforcement in light weight structure.
7. Mass loss the coir reinforced slab weight of 360.40 N and coir coated with epoxy slabs gave 361.70 N. These values are reduced by 3.16 % and 3.63 % with respect to conventional slabs. So coir is considered to be reinforcement.

8. In the four varieties of reinforcement used in the composite slab, coir and coir coated with epoxy have the strength value of 32.62 kN and 35.80 kN. These values are reduced by 15.86 % and 31.58 % when compared with Steel and GFRP reinforced slabs. These values are limited to one. So coir can be used for low cost construction.

9. The influence in concrete strength for the various types of reinforcement has been discussed. If steel is used as reinforcement, the strength increased about 23.50% and the GFRP increasing the strength by about 15.50% while increased the percentage of reinforcement. But when coir and coir coated with epoxy are used as reinforcement the strength increased by 18.38% to 27.23%. So coir and epoxy coated coir have a better bond between the concrete composites.

10. When the thickness of element increases, it increases the strength of the composite slab. If GFRP, Steel Coir and Coir coated with epoxy are used as reinforcement in the slab, by increasing the thickness from 40mm to 60mm, it improves by 63% 65% 61% and 61% in strength. There is no more variation in between them. So the coir and coir coated with epoxy can be used.
11. The load-deformation characteristics obtained from Finite Element Analysis using ‘ANSYS 10’ were almost closely in agreement with experimental results.

12. SEM and EDS analyses confirmed the boundary of fibre-matrix transition zone that has an excellent adhesion. The impregnation of calcium content on the fibre walls showed better strength enhancement.

13. Hence coir rope can be used as reinforcement in concrete slabs for light weight modular structure only. Since a proper design procedure has not been developed, it can be used in non-engineered construction only.

14. This is a basic study. More number of research works are to be carried out on this topic for 100% implementation of such composite panels in actual construction.

7.3 SCOPE FOR FURTHER WORK

In the years to come, researchers could do well by highlighting these aspects of research:

- Coir mesh can be reinforced in two layers. This may increase the performance of the composite panel.

- As the scope of the present study is limited to flexural behaviour of composite panel, it can be extended to other structural components like wall panels also.
- In this study the slabs are subjected to static flexural loading, but the performance of such slabs is to be studied in cyclic loading behaviour.

- The effect of high performance concrete needs to be used in the composite panels.

- In this study thickness of panel is taken as 40 mm and 60mm. In the future, it may extend up to 100mm and more and the response may be studied.

- The diameter of coir reinforcement is selected as 8mm in this study. So different diameters such as 6mm, 10mm, 12mm, 20mm etc., may be studied.

- The long-term effects of GFRP/coir reinforcement may not lead to failure aimed at the short-term design or may lead to uneconomical designs. It is therefore essential to develop appropriate design provisions that take into account the long-term behaviour of GFRP/coir reinforcement.

- The long-term properties of GFRP/coir reinforcements under different exposure conditions with different types of percentage and matrix composition need to be assessed by rigorous experimental study.

- When these panels are used in modular housing, connections become the major parameters. So studies on provision for connections are to be made.