

A Comparison of Conventional and Ferrocement Soil Retaining Structure

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Abstract - The conventional RCC soil retaining structure has got its certain drawbacks of being too heavy and costly. This paper deals with use of ferrocement as an alternative to conventional RCC soil retaining structure. An analytical study is carried out using Geometric software to compare ferrocement soil retaining structure with geometrically identical Conventional RCC soil retaining structure. Ferrocement is advantageously used for its less thickness and flexibility to mould in required shapes. We can use full sectional strength of ferrocement in analysis of structure using optimum geometrical configuration. In the research work, Conventional RCC structure is also compared with rectangular and arch shaped ferrocement soil retaining structure of 50 mm thickness and 5m height, with a retaining soil density of 18kN/m³. The results showed that in arch shaped face and base wall structure, deflection and stresses are very less and within permissible limits. Due to reduced thickness of members, requirement of material is less and thus found to be more cost-effective than RCC soil retaining structure.

Key Words: RCC, Ferrocement, Retaining wall

1. INTRODUCTION

Walls built for backing granular solid material like soil, earth loose stone, sand, coarse aggregate, coa; grains etc called Retaining walls. Loads of these materials when piled together will not remain in a vertical face. They have tendency to slide down and repose themselves to a particular inclination. Soils in cutting or embankment have got the same tendency of sliding down. When such embankments and cutting or loads of granular materials are to be kept in vertical position, there should be supporting structure to keep the material from falling into an inclined repose formation. The conventional type of retaining wall are made of brick, stone masonry and RCC cantilever and counterfort retaining walls are constructed depending upon vertical heights of retaining material to be supported. These retaining wall having heavy, bulky foundation, also required more time for construction. Therefore, alternative

material as ferrocement is came as good alternative in which time for construction, weight of the structure and cost can be reduced as compared to RCC cantilever and counterfort retaining wall. Ferrocement is basically composed of reinforcement and mortar, one is naturally desirous to compare it with reinforced concrete. RCC is a heterogeneous composite. After first crack, steel and concrete share the load separately and the design is based on concrete taking compression and steel taking tension. In ferrocement due to strong bond between wire meshes and mortar, even after the first crack steel and mortar act together as homogeneous material. Up to the yield of steel wires, strains in steel and mortars are same.

1.1 Ferrocement

Ferrocement can replace all types of construction material. It is thin walled and continuity and placement of equal mesh reinforcement in both directions make it possible to achieve high equal strength in both the direction. It can be moulded in any shape and size. Its strength to weight ratio in tension and compression is very low. There is various advantage of this material which make it best alternative of RCC. In this project work comparison of conventional RCC retaining wall is done with ferrocement retaining wall, for comparing some common data is adopted like height of wall is considered as 5m, soil retained by wall having density 18kN/m³ backfill supported by the wall is on counterfort side depth of surcharge is considered equal to height of stem and backfill is assumed to be horizontal. By considering all this data for various geometrical configuration, optimal geometrical configuration needs to be find out and after that parametric study on optimal section is done.

3.1 Design Difference in RCC and Ferrocement

Comparison of this type is absurd as the two materials are quite different. But many have designed the ferrocement members by treating them as RCC and so this study is unavoidable.

1. Matrix:

- a) RCC: Cement concrete. A brittle composite and so after first crack, no further load is taken.
- b) ferrocement: Cement mortar. No coarse aggregate. Ductile up to yield of mesh reinforcement and can take loads even after first crack.

2. Reinforcement:

- a) RCC: Bar type with very little area of contact for bond with concrete. Hence design is required to be checked for bond and shear.
- b) ferrocement: Continuous fine wire meshes used as reinforcement. Fine wires increase the area of contact enormously and a perfect bond between mortar and wires make all the difference. Continuity of meshes avoids pull out of meshes and crack widths are controlled. Meshes are not embedded into mortar but they contain and encase the mortar. Higher percentage of steel up to 8% is possible.

3. Structural behaviour:

- a) RCC: It is heterogeneous. Each constituent acts separately as a discrete particle. Steel takes tension and concrete takes compression. One won't improve the property of the other or that of the composite.
- b) ferrocement: It is homogeneous. It has isotropic properties in two directions. It is a perfect two-phase composite. Strong bond between wires and mortar make them to act as a one single material. Each constituent improves the property of the other and also that of the final composite. They share the load through strong bond. Ductility increases with increase in volume fraction and specific surface of steel. This is quite a different behaviour. In RCC lower ductility is observed when reinforcement ratio is increased. Over-reinforced RCC beams fail by crushing of concrete.

4. Stress distribution on section:

- a) RCC Section divided in two sections, one compression zone and the second tension zone. Neutral axis shifts as the area and location of steel is changed.
- b) ferrocement: As the meshes are disbursed uniformly throughout the section of the member and being bonded strongly with mortar, ferrocement can be looked upon as single mortar block with the equivalent area of steel, i.e. ($m_f \times A_s$), added to it. Neutral axis will be at the centre of gravity of the section.

5. Stress-strain relation in tension:

- a) RCC: Linear up to first crack. It cannot take further loads. Steel and concrete act separately.
- b) Ferrocement: Three phase behavior is clearly observed. Bond between steel and mortar is distinctly observed up to yield point of steel.

6. Load deflection behavior in flexure:

- a) RCC: After the rupture, no further bending moment can be taken. The curves start drooping down.
- b) ferrocement: Three phase behavior is clearly observed. Rupture stress extends up to the yield point of steel.

METHODOLOGY

4.1 General

This project work includes comparison of conventional Reinforced Cement Concrete retaining structure and Ferrocement soil retaining structure. Also, parametric study on arch shaped stem and base ferrocement soil retaining structure. For comparing Reinforced Cement Concrete structure with Ferrocement structure, retaining wall of 5m height with soil density of 18 kN/m³ is considered. For Reinforced Cement Concrete retaining wall other dimensions of structure is calculated by manual analysis.

results are evaluated.

After analysis results are considered in the form of deflection, shear stress and direct stress and all the comparison is done by considering these parameters only at various positions of stem base and counterfort.

Following are figures shown of various retaining walls:

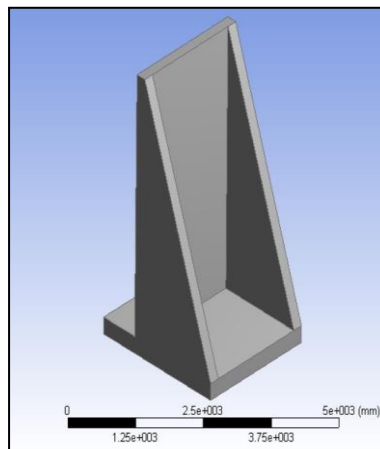
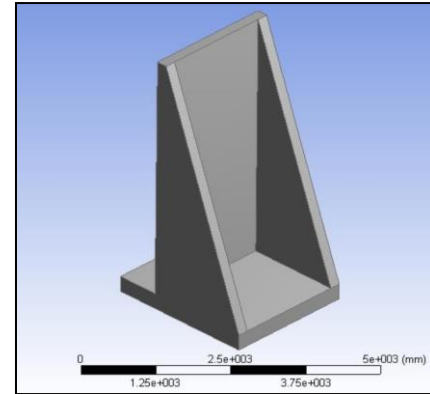
Height of retaining wall =5m, Thickness of stem=200mm Thickness of counterforts=200mm, Thickness of heel and toe = 300mm Counterfort spacing =2000mm

Depth under soil =1000mm

Length of heel=1750mm

Length of toe =800mm

Fig.4.1 RCC Rectangular Retaining Wall



Height of retaining wall =5m Thickness of stem=200mm Thickness of counterforts=200mm Thickness of heel and toe = 300mm

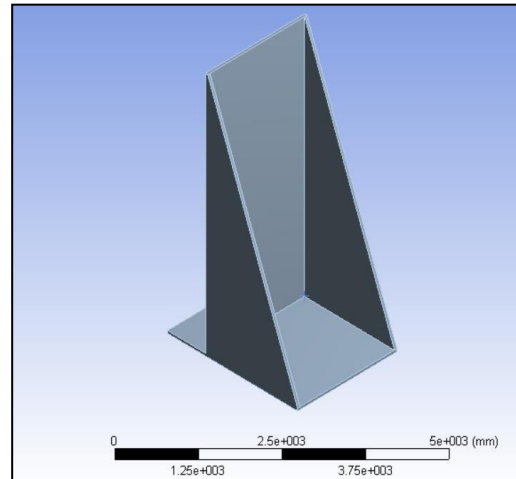
,Counterfort spacing =2000mm Depth under soil =1000mm

Length of heel=1750mm

Length of toe =800mm

Fig.4.2 Ferrocement Rectangular Retaining Wall

Height of retaining wall =5m
 Thickness of stem=50mm Thickness of counterforts=50mm
 Thickness of heel and toe = 50mm
 Counterfort spacing =2000mm
 Depth under soil =1000mm
 Length of heel=1950mm
 Length of toe =800mm



.4.3 Ferrocement Rectangular Retaining Wall of 50mm Thickness

5.1 Deflection Comparison Results

Results showing deflection in stem within RCC and ferrocement structures at various position of stem:

Table 5.1 Deflection of stem at various position in all the types of retaining wall

Sr. No.	Height (m)	RCC	Ferrocement of same dimensions	Ferrocement with 50mm thickness	Arch stem retaining structure	Arch stem and base ferrocement retaining Structure
1.	0 Bottom	0	0	0	0	0
2.	2.5 Middle	0	0.0769	3.43	0.511	0.016
3.	5 Top	0	0.0512	1.14	0.767	0.029

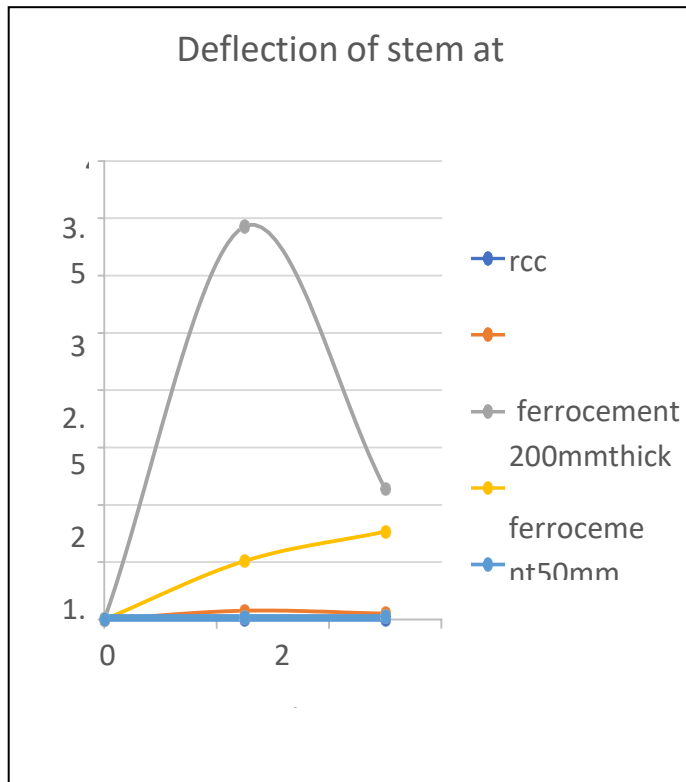


Fig.5.1 Deflection at various position of stem

Table 5.2 Direct stresses in stem within RCC and ferrocement structures at various position of stem

Sr. No.	Height (m)	RCC	Ferrocement of same dimensions	Ferrocement with 50mm thickness	Arch stem retaining structure	Arch stem and base ferrocement retaining structure
1	0 Bottom	0.08	0.115	3.2	0.433	0.3
2	2.5 Middle	0.196	0.248	1.22	0.125	0.0243
3	5 Top	0.010	0.0201	0.52	0.094	0.0469

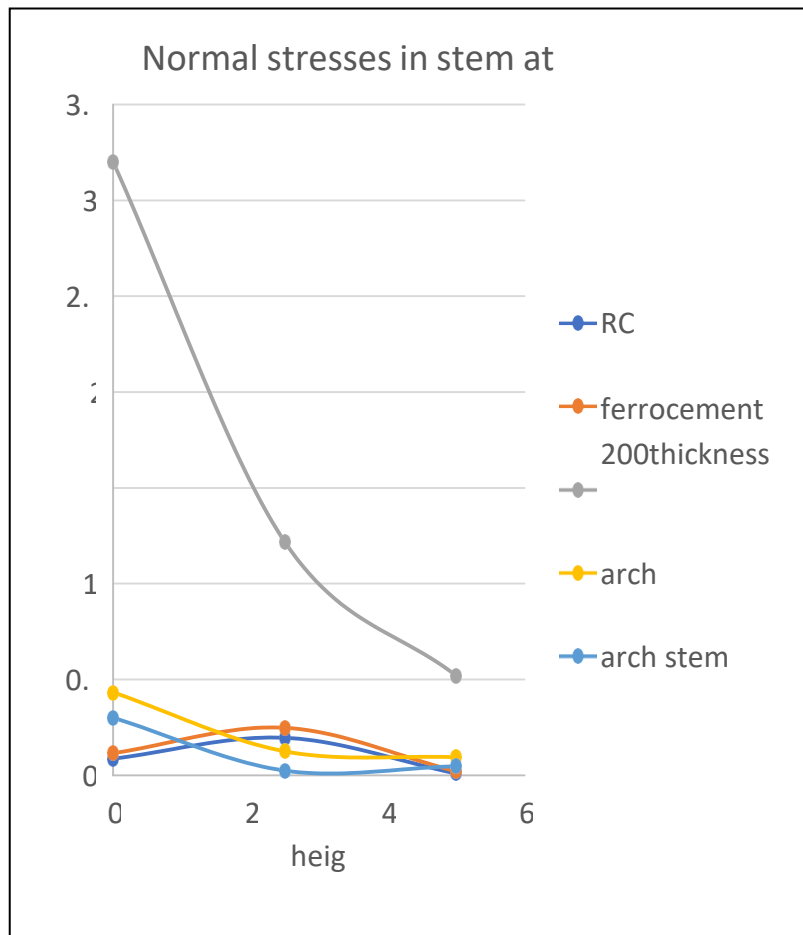


Fig.5.3 Direct stresses in stem within RCC and ferrocement structures at various position of stem

Table 5.3 Shear stresses in stem within RCC and ferrocement structures at various position of stem

Sr. No.	Height (m)	RCC	Ferrocement of same dimensions	Ferrocement with 50mm thickness	Arch stem retaining structure	Arch stem and base ferrocement retaining structure
1	0 bottom	0.008	0.038	0.25	0.012	0.029
2	2.5 middle	0.06	0.141	0.84	0.084	0.048
3	5 Top	-0.095	-0.064	-0.34	0.195	0.12

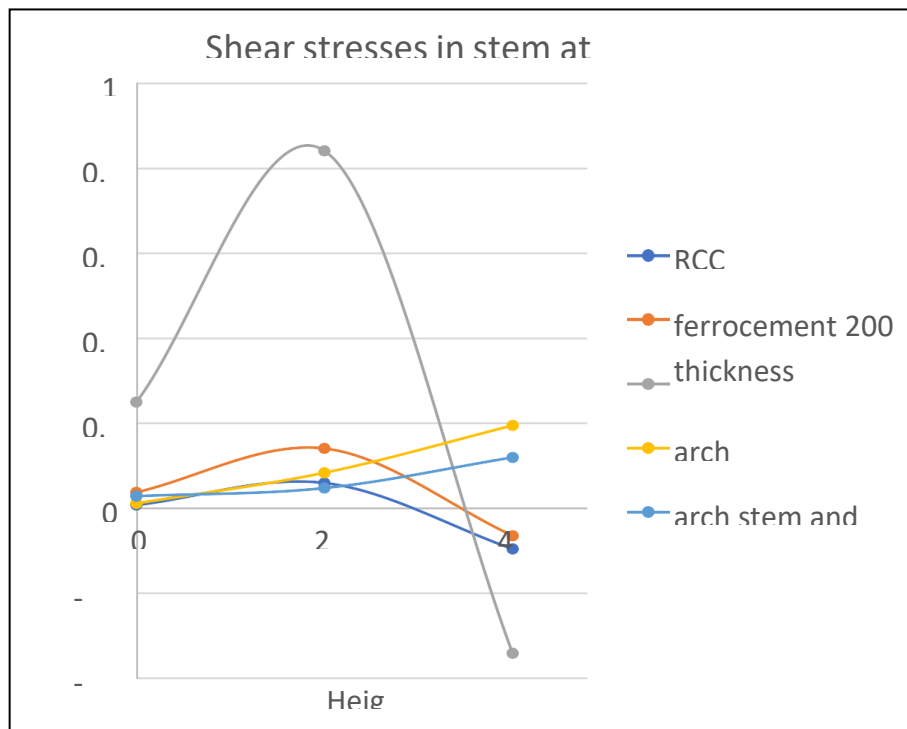
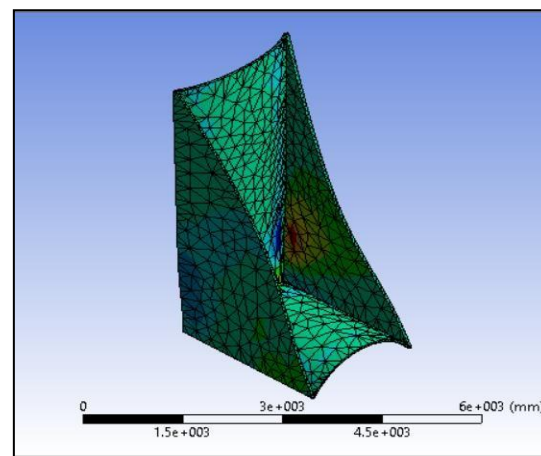
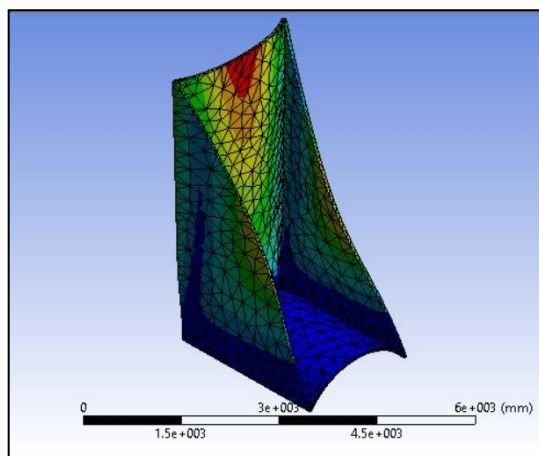


Fig.5.3 Shear stresses in stem within RCC and ferrocement structures at various position of stem

Table 5.9 Variation in maximum deformation, direct stress and shear stress for different heights of retaining wall

Sr. No.	Height	Total deformation (mm)	Direct stress (MPa)	Shear stress (MPa)
1	3	0.109	0.327	0.24
2	4	0.3428	0.477	0.365
3	5	0.672	0.761	0.62
4	6	0.94	1.042	0.87
5	7	1.54	1.116	1.29



(a) Deflection (b) Direct Stresses Fig 5.9 Arch Face and Base Counterfort Retaining Wall

CONCLUSIONS

1. Deflection is observed at top surface of stem.
2. Direct stresses are maximum at middle height of counterfort from inside in all the types of retaining wall.
3. Shear stresses are maximum at middle height of counterfort from outside in all the types of retaining wall.
4. Values of deflection and stresses of ferrocement rectangular retaining wall with same dimensions as RCC is more than conventional RCC retaining wall.
5. Very large deflections and maximum direct stress values are observed in rectangular shaped ferrocement counterfort retaining wall with 50mm thickness, hence application of rectangular shaped ferrocement retaining wall with less thickness is unsafe.
6. Values of deflection and stresses ferrocement arch stem and base retaining wall is less than ferrocement arch stem and rectangular base retaining wall

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