ABSTRACT
This paper presents a study of reinforced concrete pipe with the application of continuous glass fiber reinforced polymer sheet (GFRP). The pipe material is considered to be composed of reinforced concrete and the pipe is strengthened by using glass fiber reinforced polymer sheet. The reinforced concrete pipe is analyzed with different layers of externally applied GFRP sheet. Analysis is carried out in commercially available ANSYS software. A finite element model is developed for the pipe wherein the material properties as mentioned are used. The solid 186 layered structural solid element has been used for discretization of the model. Two sets of GFRP sheets (4 layer & 8 Layer) were considered for the analysis. Results obtained were compared with the controlled pipe made up of reinforced concrete. Results are presented for simply supported boundary conditions for the pipe. The deformation and stress distribution across the pipe has also been analyzed.

Keywords
Reinforced Concrete pipe, Ansys, GFRP sheet.

1. INTRODUCTION
Now a days, strengthening of concrete structure is one of the challenging problem in civil engineering applications. In the past a large number of structure constructed using the older design codes which is unsafe according to new design codes. Since replacement of such huge structure experiences large amount of money and time, strengthening has become the suitable way of improving their load carrying capacity and service life. Selection of strengthening method is one of the important aspect in strengthening of concrete structure. It enhances the strength and serviceability of the structure while addressing limitations such as constructability, building operations and budget. Structural strengthening may be required to allow for higher load to be placed on the structure. strengthening may required to resist loads that were not anticipated in the original design like loads resulting from wind and seismic forces. Sometimes additional strength may required due to deficiency in the structure i.e. result of deterioration, structural damage or error in the original design or construction.

Typical strengthening technique such as section enlargement, externally bonded reinforcement, post-tensioning and supplemental supports may be used to achieve improve strength and serviceability. Fiber reinforced polymer application is a very effective way to repair and strengthen structures that have become structurally weak over their life span. FRP repair system provide an economically viable alternative to traditional repair systems and materials. The use of FRP sheets or plates bonded to concrete beams has been studied by several researchers.

Jian Chen [1] investigated the behavior of concrete member using CFRP fabric jackets by both analytical and experimental approaches. A series of CFRP wrapped concrete cylinder tests were conducted to study the compressive stress-strain behavior for CFRP confined concrete members. By using the CFRP fiber increase the overall tensile strength of concrete.

K. Olivova, J. Bilicik [2] observed the strengthening of reinforced concrete column with carbon fiber the same peak load will be taken by confine and unconfined column presented but the lateral deflection of confined column is less due to formation of jacket. The deflected shape at peak load is symmetrical and no eccentrically buckling occurred Romuald-Kokou Akogbe [3] conducted study to size effect of compressive strength of CFRP confined circular concrete cylinder. The experiment included testing under pure axial load which gives better results for medium size specimen.

Murali G. and Pannirselvam N.[4] made an attempt to address an important practical issue that is encountered in strengthening of beams with different type and different thicknesses of fiber reinforced polymer laminate Houssam et al., [5] investigated the long-term durability of concrete beams externally bonded with FRP sheets on the performance of FRP bonded concrete beams and on the bond between the fibre and the concrete.

2. FINITE ELEMENT MODELLING
The reinforced concrete pipe with GFRP sheet considered here is modeled in the commercially available ANSYS software (ANSYS 15.0). The ANSYS Design modeler was used to generate the pipe with GFRP sheet model. The Pipe dimension for the model was considered in accordance with the ASTM standard. Fig. 1 explains the 3D pipe model in the ANSYS platform for the present analysis.

The material properties of the reinforced concrete and GFRP sheet are different. The structure acts as a composite layer. So both concrete pipe and GFRP sheet are modeled differently and different material properties were applied. Isotropic material properties were considered for the pipe model. The solid 186 layered structural solid element was used for discretization of the pipe model as shown in Fig. 2. This Solid 186 is a higher order 3-D 20-node solid element that exhibits quadratic displacement behavior and is defined by 20 nodes each having three degrees of freedom. Hexahedral mesh has been employed for the model and the quality of the mesh was checked by the orthogonal quality of the elements and their skewness. Fig. 3 represents the meshing of the pipe model.
The material properties used for the present analysis are shown in Table 1. Reinforced concrete was considered for the analysis of pipe which is assumed to be linearly elastic and isotropic. Epoxy-fiber is used for the GFRP sheet. Hydrostatic pressure of 125 Mpa was applied inside the pipe diameter. A simply supported boundary condition was assigned at both ends of the pipe. Bonded contact was considered at the interface between concrete pipe and GFRP sheet.

<table>
<thead>
<tr>
<th>Material properties</th>
<th>Reinforced concrete</th>
<th>GFRP sheet</th>
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<tbody>
<tr>
<td>Young’s Modulus (E)</td>
<td>34 GPa</td>
<td>11.3 GPa</td>
</tr>
<tr>
<td>Poisson's ratio (v)</td>
<td>0.3</td>
<td>0.3</td>
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</tbody>
</table>

The results obtained were compared with the reinforced concrete pipe with GFRP sheet and without GFRP sheet. One important aspect of the present study is to investigate the deformation and stress distribution along the pipe. The total deformation of the pipe without GFRP sheet, GFRP sheet of 4 layers and GFRP sheet of 8 layers are 3.14mm, 3.026mm and 2.9mm. Correspondingly the von-mises stresses are 1109.5Mpa, 1087.8Mpa and 1070.7. The variation of total deformation and stresses are explained in Fig. 5(a) & 5(b). It may be observed from Fig 5 that, in case of reinforced concrete pipe without GFRP sheet the total deformation and stresses are high comparison with those applied with GFRP sheet of different layer and again least deformation and stresses observed in case of GFRP sheet with 8 layer. Hence increasing the stiffness of the material.

3. RESULTS & DISCUSSION

In this present investigation results were presented for the reinforced concrete pipe with GFRP sheet. Static load is considered for the analysis. The total deformation and von-mises stress of the model is shown in Fig. 4(a) & 4(b).
4. CONCLUSION

This paper is devoted to the analysis of reinforced concrete pipe with the application of continuous glass fiber reinforced polymer sheet (GFRP). Analysis has been carried out on the modeling of concrete pipe with and without the application of GFRP sheet. The material properties of both the material are assume to be homogeneous and isotropic in nature. Reinforced concrete pipe and two sets of GFRP sheets (4 layer & 8 Layer) is modeled in ANSYS environment. Results are presented for simply supported boundary condition. The results (deformation & stresses) obtained in Pipe with externally applied GFRP sheet are compared with reinforced concrete pipe without GFRP sheet. From the result it may be concluded that Pipe applied with GFRP sheet is more stiffer in comparison with pipe without GFRP sheet. Hence provides more resistance to the formation of crack.

5. REFERENCES


