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Experimental Investigation In CFRP For Application In Retrofitting of Diaphragm Wall Structure

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Abstract

Repair and Retrofitting using Carbon Fiber Reinforced Plastic Composites is a new technique increasing used for reinforced concrete structures. This Paper discusses repair and strengthening of damaged diaphragm wall structure which is affected by Bentonite ingress during construction of the wall. This Problem occurred in site which was identified through technical investigation. Rectification of damaged concrete structure on exterior wall face can be repaired by Jet Grouting and FRP application for improving its durability. Detailed Experimental investigations are done and Numerical analyses are performed using ANSYS software to simulate Diaphragm wall structure strengthened by carbon fiber reinforced plastic composites applied at the repaired surface. The results shows that there is a marginal improvement on walls which proves that this is the effective method for retrofitting works.

Keywords: Diaphragm wall, Bentonite, CFRP, Rehabilitation, ANSYS

Introduction

Diaphragm walls are reinforced concrete structure constructed using bentonite solution to temporarily support an open trench. Nowadays Diaphragm walls are constructing even for a depth of 100m.Construction sequence of diaphragm wall are initially fixing the alignment and constructing the guide wall. Soil will be excavated for a required depth. Bentonite slurrys allowed to flow for removing soil slurry and Rein for cement cages will be lowered alternatively to the trench following to stop end fixing. Finally Concrete will be poured and stop ends were removed. The imperfection in the diaphragm walls occurs due to improper concrete placement. It should be avoided by proper investigation.

Carbon Fiber Reinforced polymers are composite material. It consists of 2 parts that is matrix and reinforcement. Carbon fiber is a reinforcement which impart strength and rigidity. Epoxy is a polymer resin acts as matrix used for binding the

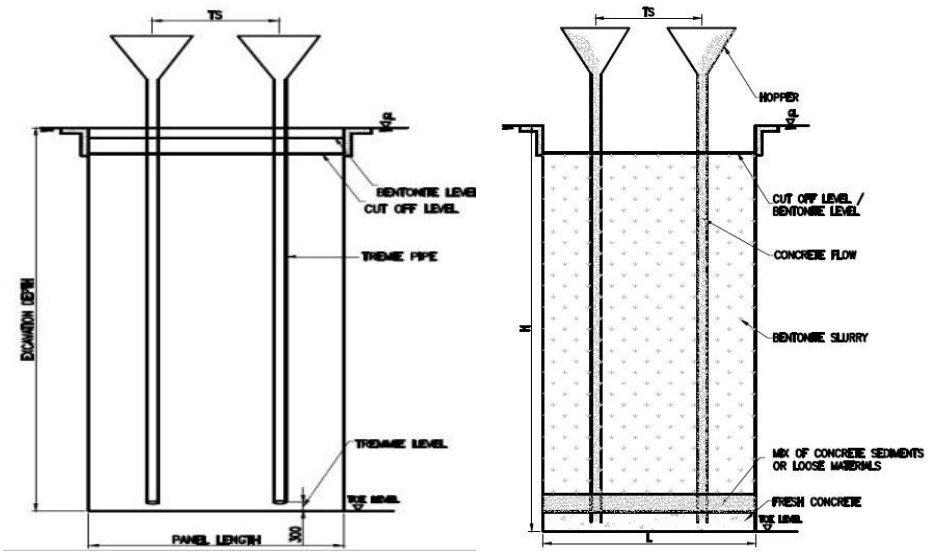
carbon fiber. CFRP is extensively used in Aerospace engineering, Automative engineering, civil engineering, carbon fibre micro electrodes, sports goods etc., It is little expensive but it is highly durable.

Literature Review

There are several reasons for the damages in diaphragm wall Structure. Some of the studies are included which gives clear idea about the causes of damages and retrofitting measures. James C. Ni , Wen-Chieh Cheng.,(2012) discusses the leakages occurred in the diaphragm wall of TRTS and its corrective measure. Initially emergency grouting were carried out over the damaged areas but it was controlled. So further seal grouting and voidfilling grouting were undertaken which controlled the leakage. Hsii-Sheng Hsieh et.al. (2003) explains the use of jet grouting to limit diaphragm wall displacement during excavation.In this project, Partially jet grouted in and around the soil mass which controls the displacement. Jet grout Piles with diameter of 0.6m and spacing at 2m has been constructed in site. This technique is called as one fluid system. Guney et al. (2004) describes about retrofitting the existing reinforced concrete structure which was affected by earthquake. CFRP fabrics were used for strengthening the damaged structure. CFRP anchors has been used to fix the sheets to the wall. This CFRP sheets increased the strength of damaged structure rapidly found out by experimental analysis.

Causes of Damages

Tremie concreting systems are deployed for the casting of diaphragm wall. During the process of concreting, ensuring the tremie pipes are fully embedded within the poured concrete. If that was not maintained, formation of bentonite contaminated concrete pockets may happen.



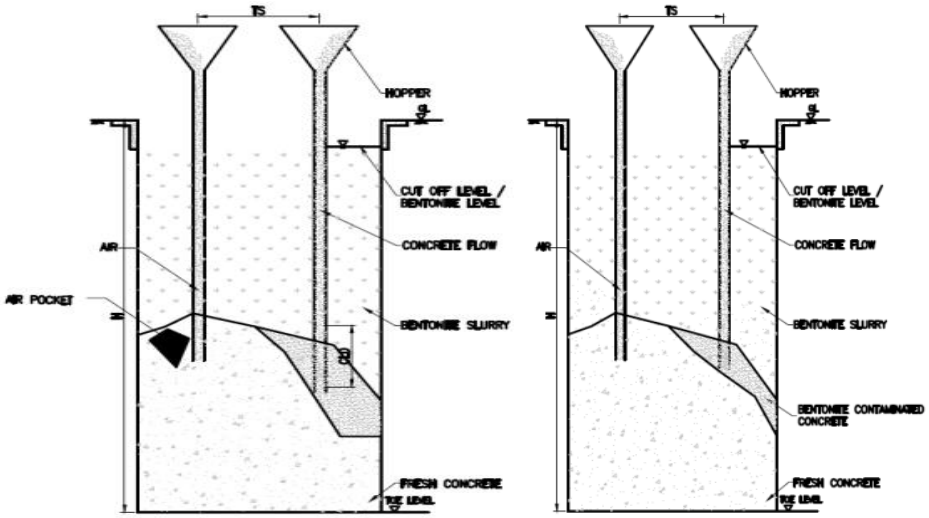


Figure 1: Placing of Concrete through Tremie Pipes

Proposed Treatment For Damaged Diaphragm Wall

It is Probable that leaks will occur during the construction of diaphragm wall.The types of leaks and severity are difficult to predict but may be broadly classified as follows:

Type 1 : Point leaks at individual location with low to moderate water flow

Type 2 :Leaks at construction joints with low to moderate water flow

Type 3 : High pressure large volume water leaks

Type 4 : Water Seepage over wide areas.

For each type, different injection method and different materials may be used to stop the leak and seal the concrete.

The main objectives of all procedure are to permanently to stop water flow and seal the concrete surface in the most efficient and cost effective manner using minimum amount of material and in the shortest time possible to enable work to continue.

Type 1 leaks will normally associated with one or more of the following situations:

- Voids as a result of poor compaction / segregation.
- Presence of rock anchors or similar embedded elements.
- Voids or Cracks resulting from cold joints.

Mc-Injekt 2033(a foaming polyurethane)to temporarily halt the water flow followed by injection of Mc-Injekt 2700L

Type 2 leaks are usually associated with that have been deformed during the pouring and vibration of concrete. When leakage joint is more than a metre the use of Mc-Injekt GL 95 TX TR will be required.

Type 3 leaks are usually the result of poor concrete compaction or flowing water before concrete has hardened sufficiently or in extreme cases ground movement or failure of the concrete to displace the bentonite. Mc-Injekt 2700 or one of its variants will be sufficient to repair it.

Type 4 leaks will normally associated with large areas of Honeycombed Concrete, extensive interconnected cracks and cold joints. To seal these areas the injection of MC-Injekt GL95 TX TR via grid pattern of packers. The material will be pumped through the entire width of the wall to form a water proof membrane on the Surface in contact with the ground.

Sample Preparation For Rehabilitation

Jet Grouting

It provides a curtain by pumping cement grout into damaged surface to stabilize or strengthen it. Proposed Job Mix Formula for M50 grade concrete of Repair works (Cement Grout).

Target Strength for Mix Proportioning

Fck' = fck + 1.65 * S ,
Fck' is a target average compressive strength at 28 days,
fck is Characterstic Compressive strength at 28 days,
S is Standard deviation(5Mpa)
Therefore, Target Strength = 50 + 1.65*5 – 58.25Mpa

Table 1: Mix Proportions

Materials	**Weight(kg/Cum)**
Cement	380
Fly ash	130
Water	168Kg
12.5mm	1050Kg
Natural Sand	708Kg
Chemical Admixture	5.1Kg

Table 2: Sampling Details

Samples	**Test**	**Number of Samples**
1.2mX0.15mX0.10m	Flexural Strength	2
0.15mX0.160m	WPT	2
0.10mX0.20m	RCPT	2

Fibre Reinforced Polymer

CFRP Application

RC Samples has been kept cast and cured for 28 days. After its curing has been over, application of CFRP sheets works will be initialized. Retrofitting should be done in

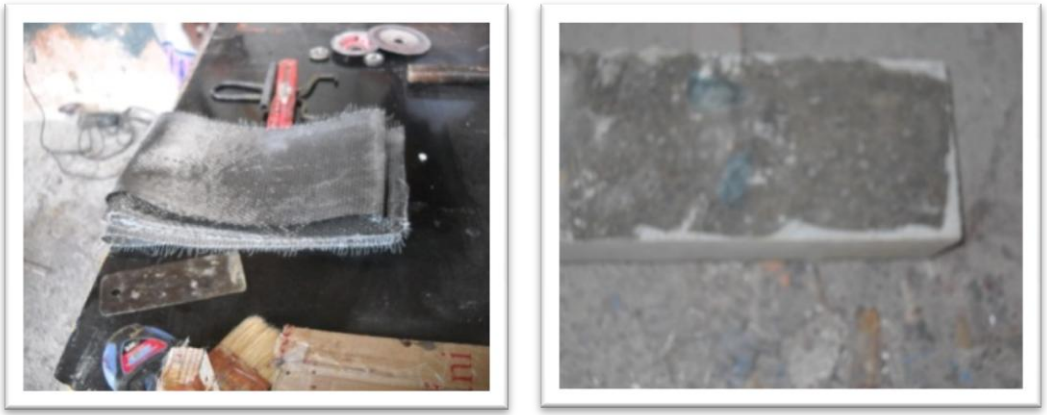
bottom surface of the cured beam. Surface of the specimen made to roughen by machine and cleaning have been done on all the specimen. The cleaned surface has been applied with polymer resin epoxy and hardener. Hand mixing has been performed. After this surface preparation, CFRP sheet has been pasted on the bottom surface using adhesive. Following this steel rollers were pressed over the specimen to remove the air voids. It should be cured for 3 days after the bonding stage over.

Table 3: Properties of CFRP Sheet

Mechanical Property	**Values**
Density	1760 Kg/m³
Thickness	0.00013m
Elongation at break	1.6%
Tensile strength	4.3GPa
Tensile E-modulus	238GPa

Table 4: Sampling Details

Samples	**Test**	**Number of Samples**
1.2mX0.15mX0.10m	Flexural Strength	2
0.15mX0.160m	WPT	2
0.10mX0.20m	RCPT	2



(a) (b)

Figure 3: (a)CFRP Sheet (b)Surface Preparation

Figure 4: CFRP on the bottom of the beam

Test on Hardened Concrete

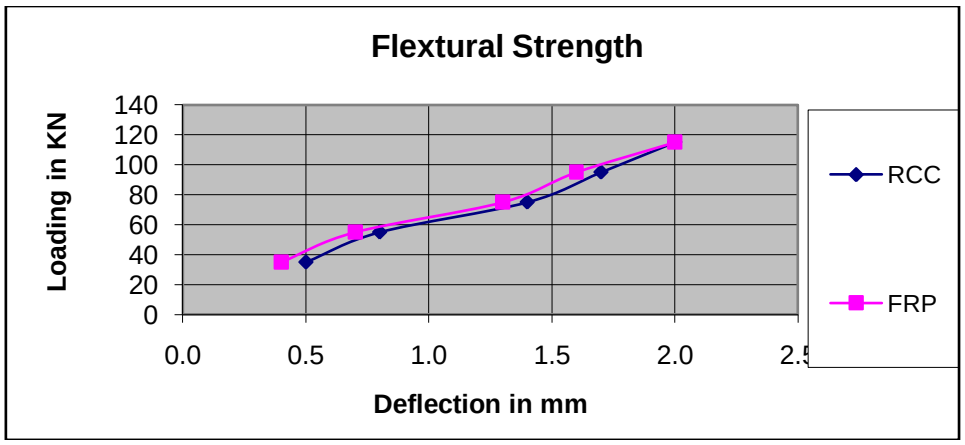


Figure 5: Flexural Strength

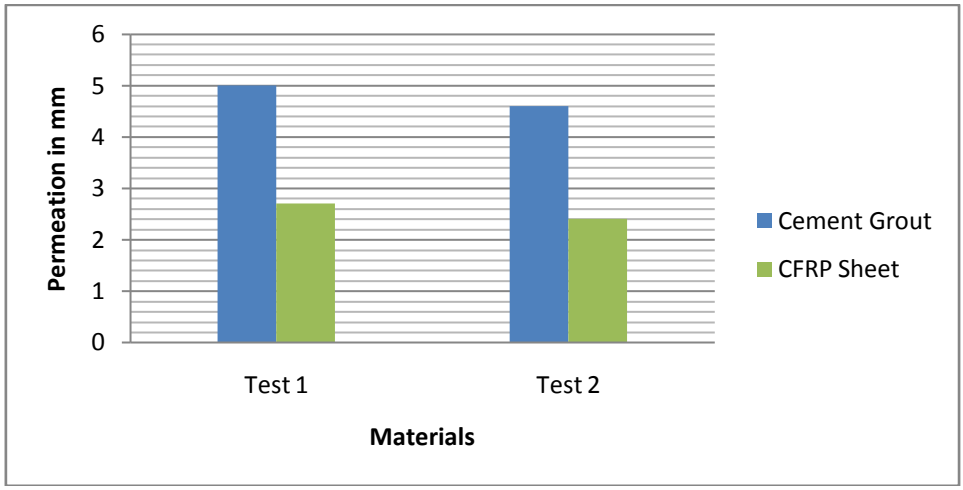


Figure 6: Water Permeability

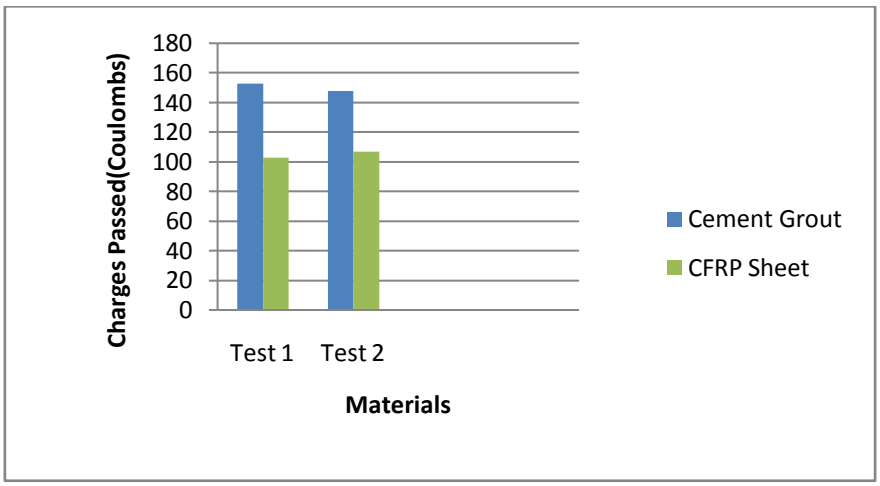


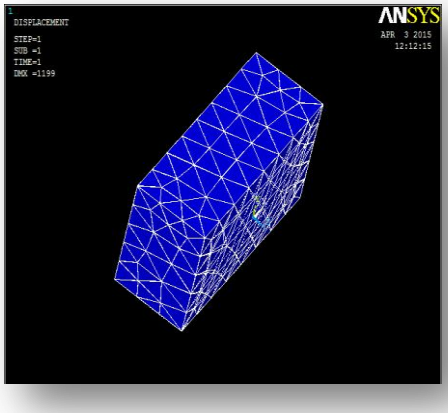
Figure 7: Rapid Chloride Penetration

Finite Element Analysis

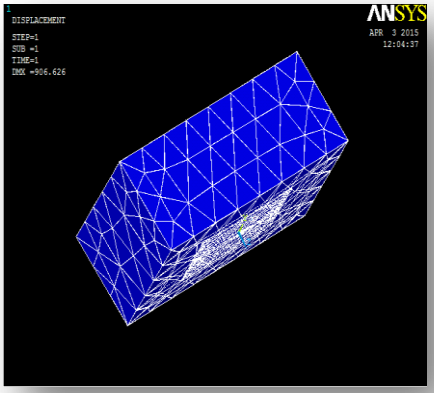
Finite element analysis has been done to model the diaphragm wall Structures. ANSYS Software is used for the deformation analysis. Analysis is done for Reinforced concrete wall with externally bonded CFRP.

Table 5: Material Properties

S.NO	Type of element	Properties	
1	Solid 65	Linear Isotropic	
		EX	35.35GPa
		PRXY	0.2
2	Solid 46	Linear Isotropic	
		EX	230GPa
		PRXY	0.28
3	Link 8	Linear Isotropic	
		EX	212.5GPa
		PRXY	0.3
		Bilinear Isotropic	
		Yield Stress	0.415GPa
		Tangent modulus of elasticity	0.02GPa

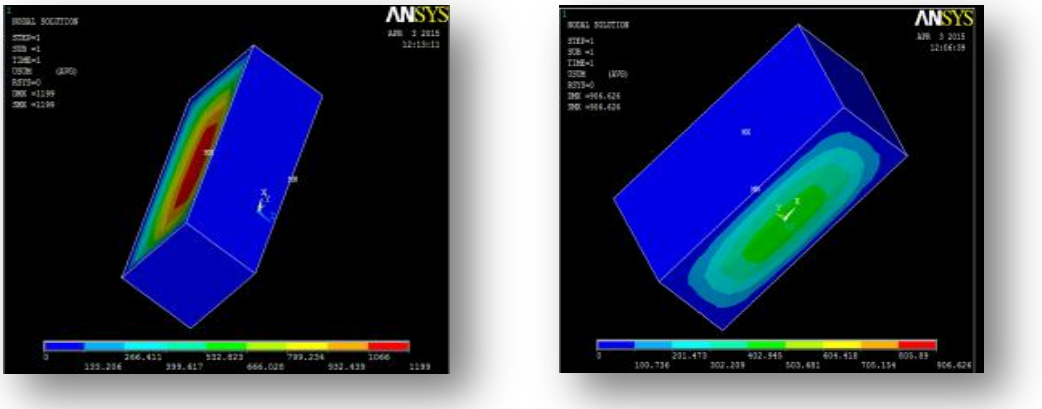


a.Diaphragm wall without CFRP



b. Diaphragm wall with CFRP

Figure 7: Mesh Generation



a.Diaphragm wall without CFRP b. Diaphragm wall with CFRP

Figure 8: Deformation Analysis

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Conclusion

Based on the extensive laboratory investigation and ANSYS software analysis it was found that rehabilitation by jet grouting and CFRP application proves that this is a best feasible option than the other methods. . So the future possibility of applicability of CFRP sheets in Civil engineering field will be highly beneficial.

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