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Preparation of 3D RC Frame Structural Model Made From Crumb Rubber Concrete for Seismic Test

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ABSTRACT: Waste rubber tyres are discarded and dumped in colossal masses everywhere in environment. These rubber tyres are important source of pollution. They produce harmful gases by burning it in kilns. One of the recycling techniques of these scrap rubber tyres is to incorporate it in crumb form in concrete as a partial replacement of concrete aggregates which is known as crumb rubber concrete (CRC). In the current research study, two 1:3 scaled down space (3D) reinforced concrete special moment resisting frame (SMRF) structures were prepared; one from usual concrete and one from crumb rubber concrete. Both models were constructed on a reinforced concrete (RC) foundation base having a concrete ratio 1:2:4 with w/c 0.42 while the super structure of both frame structures were constructed with a concrete mix ratio of 1:1.73:1.57 with w/c ratio 0.52 but in crumb rubber concrete frame, 15% of fine aggregates by volume were replaced by rubber powder. During the construction, 24 number standard concrete cylinders (twelve from usual concrete and twelve from rubberized concrete) were prepared from each batch of concrete to find the difference in their mechanical strengths.

KEYWORDS: Crumb Rubber Concrete (CRC), Reinforced Concrete (RC), SMRF, Pollution

I. INTRODUCTION

With the development of modern transportation industry, the number of vehicles is rapidly increasing throughout the world. From these vehicles, a large number of waste rubber tyres are put in to the environment which is producing different environmental and health problems. According to a survey in US, 1.1 scrap rubber tyre is used per person per year and is disposed in to the environment which adds up to a total of 303 Million scrap rubber tyres per year in the united states. In the report, it was concluded that 0.594 Million tons scrap rubber tyres were in the landfills in 2009 in US (RMA, 2009) [1]. According to another survey, one billion rubber tyres complete its life every year and by the year 2030, this number will increase up to 1.5 billion (Torgal et al., 2012) [2]. Only in Australia, 48 million scrap rubber tyres are exposed in environment each year (Media-Release, 2014) [3]. In UK, 37 million rubber tyres were put in to environment in 2002[4]. In Pakistan, 0.48 Million tons scrap rubber tyres are discarded in landfills each year [5]. This increasing number of waste rubber tyres needs their recycling. One of recycling technique is to first shred these tyres and then use it in concrete in place of fine or coarse aggregates up to some percentage which is known as crumb rubber concrete (CRC).

II. RELATED WORK

A lot of research work has been carried out to investigate the mechanical and dynamic properties of crumb rubber concrete (CRC). It has been find out that as compared to usual concrete, CRC has lower compressive strength, flexural strength and static modulus of elasticity [6, 7]. On the other hand, CRC has improved seismic performance. Osama

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Youssf et al., 2015 investigated that CRC columns has higher damping ratio, energy dissipation and lateral strain capacity as compared to usual concrete columns [8]. James Xue et al. 2013 tested rubberized concrete column under shake table and reported that damping ratio of rubberized concrete column was higher than usual concrete column while its compressive and flexural strength was lower than usual concrete columns [9]. Similarly many researchers has worked out on finding static and dynamic properties of rubberized concrete on material level but a very limited work has been performed on actual structural level. In this research project, a 3D reinforced concrete special moment resisting frame structural model was fabricated from rubberized concrete for performing seismic test using shake table.

III. MATERIALS AND CONCRETE MIXES

The materials used for preparation of structural models were Portland cement, coarse aggregates of maximum size 3/8 in, fine aggregates from river, crumb rubber obtained from market and potable water. The reinforcement used in foundation base were #4 deformed bars having yield strength equal to 40,000 psi while in super structure #1 and #2 deformed bars having 60,000 psi yield strength and conforming to ASTM A615 / A615M [10]. Using (ACI) Standard 211.1 [11], concrete mix design was performed which resulted in a concrete ingredients mix ratio equal to 1:1.73:1.57 and water to cement ratio equal to 0.52.

IV. METHODOLOGY

A two story, 3D special moment resisting frame prototype structure was considered. The prototype structure was first analysed and designed in ETABS V9 as shown in Fig.1 using the design requirements given in Table 1.

Table 1: Design Requirements

Material Properties		
Material	Property	Considered Value
Rubberized concrete	Concrete Compressive Strength, f_c'	3510 Psi
Steel	Steel type	Grade 60, ASTM A615
	Reinforcement Yield Strength, f_y	60,000 psi
	Steel Modulus of Elasticity, E_s	29,000,000 psi
Site	Zone	4 (0.4g)
	Soil Type	S_b (Hard Rock)

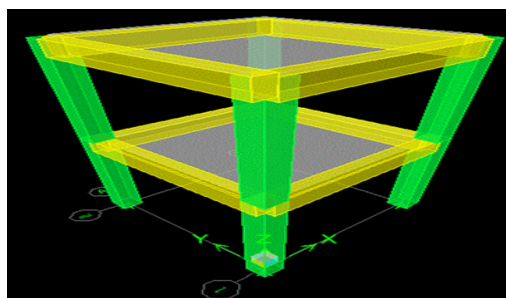


Fig 1: ETABS V9 Model

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Vol. 8, Issue 4, April 2019

Due to the limitation of pay load capacity of the shaking table available at the Earthquake Engineering Centre laboratory, University of Engineering & Technology Peshawar, Pakistan, the considered prototype structure was scaled down by a factor 3. The scaling of the prototype structure was performed by keeping in mind the simple/distorted model similitude requirements. The structural details of the scaled down model is given in Fig. 2.

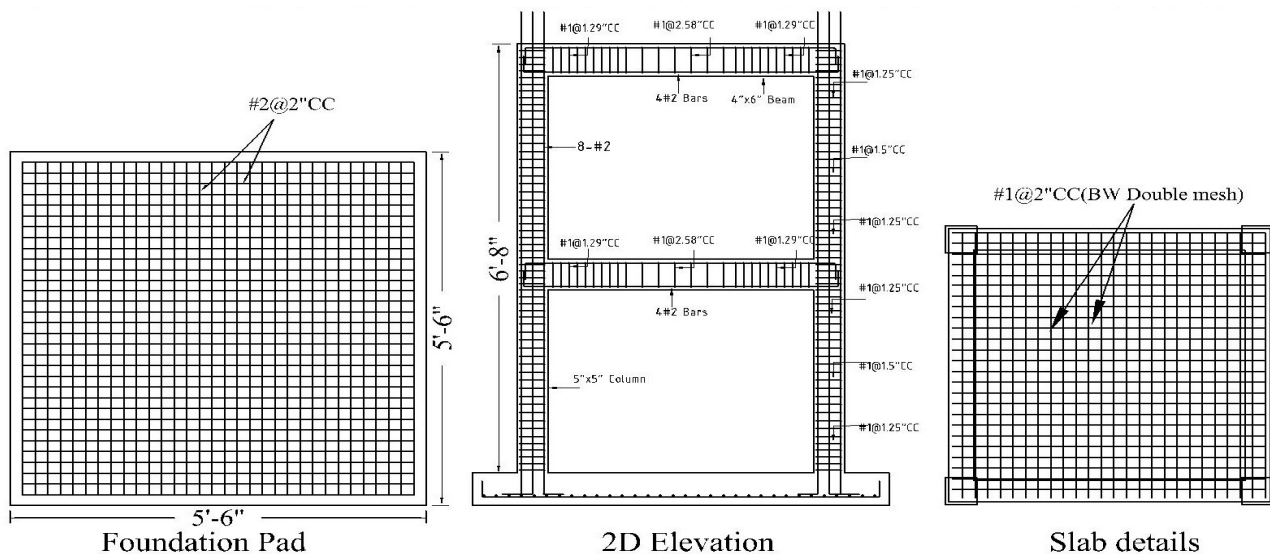


Fig 2:Structural Details of scaled model

After finalizing the design of structural model, its preparation was started in casting yard by first constructing two reinforced concrete foundation pads of dimensions 5'-6"×5'-6" and having thickness equal to 6" and reinforced with #2 deformed bars at 2" c/c in both directions. Vertical holes were lift in foundation pads in the form of PVC pipes of diameter 1" so that it may be fixed on shake table with the help of nuts and bolts. After 7 days curing of the foundation pad, the position of frame columns were marked on it and the column reinforcement cages were erected. One structural model was prepared from usual concrete and the other one was prepared from rubberized concrete which was made by replacing 15 % fine aggregates by rubber particles shown in Fig. 3.



Fig 3:Rubber particles used in CRC

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Steel formwork was used for beams and column while wood formwork was used for slab construction. After completing construction of models, plain cement concrete blocks were constructed at each floor for simulating additional masses so that vertical stresses in prototype becomes equal to vertical stresses in model which is a similitude requirements as suggested by Quintana-Gallo et al (2010) [12]. The various stages of construction are shown in Fig. 4 and 5.



Fig 4: Preparation of foundation pads and Ground Floor columns



Fig5: Preparation of First Floor columns and slabs

V. WHITE WASHING

After curing the prepared models for 28 days, they were white washed so that the cracks after tests may be visualized clearly. The final and white washed structural model is shown in Fig. 6.

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Fig 6:Complete structural model after white washing

VI. STANDARD CONCRETE CYLINDERS PREPARATION

During the construction of structural models, a total of twenty four number standard concrete cylinders (twelve from usual concrete and twelve from rubberized concrete) were prepared from each batch of concrete to find their compressive strength and the difference between compressive strength of usual concrete and rubberized concrete. The cylinders prepared are shown in Fig. 7.



Fig 7:Standard concrete cylinders

VII. FUTURE WORK

The prepared structural models will be shifted to the earthquake engineering centre with the help of fork lifter for seismic test. Shake table test will be performed on both the models by applying a real earthquake time history record and different seismic parameter will be compared for both structural models.

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REFERENCES

- [1] Rubber manufacturers association, scrap tire markets in the United States, 2009 ed. Washington, DC.
- [2] Torgal, F. P., Ding, Y. & Jalali, S. "Properties and durability of concrete containing polymeric wastes (tyre rubber and polyethylene terephthalate bottles): an overview", pp, 2012.
- [3] Media-Release. At last, a solution to Australia's mounting waste tyre problem "http://www.vacc.com.au/" [Online], 2014.
- [4] Martin W. Tyre crack-down to help the environment. UK Government Environment Agency; November 19, 2001.
- [5] United Nations Environment Program, report on waste management in Pakistan (<https://www.export.gov/article?id=Pakistan-Waste-Management>), June 2016.
- [6] Ganjian E, Khorami M, Maghsoudi AA. "Scrap-tyre-rubber replacement for aggregate and filler in concrete", Constr Build Mater 2009; 23(5):1828–36.
- [7] Kunal Bisht, P.V. Ramana. "Evaluation of mechanical and durability properties of crumb rubber concrete" Construction and Building Materials 2017; 155: 811–817.
- [8] Osama Youssf, Mohamed A. ElGawady, Julie E. Mills. "Experimental Investigation of Crumb Rubber Concrete Columns under Seismic Loading" Structures 2015; 3: 13–27.
- [9] James Xue, Masanobu Shinozuka. "Rubberized concrete: A green structural material with enhanced energy-dissipation capability" Construction and Building Materials 2013; 42: 196–204.
- [10] ASTM A615 / A615M - 18e1 "Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement"
- [11] ACI 211.1. Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete; 1991: 38.
- [12] P. Quintana-Gallo, S. Pampanin, A.J. Carr, P. Bonelli. "Shake table tests of under designed RC frames for the seismic retrofit of buildings – design and similitude requirements of the benchmark specimen" 2010 NZSEE Conference.