RESEARCH FOR RUBBER CONCRETE EFECT RC SLAB BEHAVIOR IN DYNAMIC LOADING

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***ABSTRACT*:** Slab system is very important for transmit force element to the structure. But the limitation of slab size so the noise and large deformation in static and dynamic loading will puzzle the user. Traditional method to solve the problems is to increase the thickness of slab or using the hollow slab system. The above processing methods either will increase the self-weight of structure or the floor thickness change reduction of the use space. On the other hand because avoids the influence of the natural environment in the building process. The green building and the green materials topics were positively study. How to use the recycle material is a very important topic. Because the industrialization many rubber material were applied in people's life. Massive abandons rubber will easily to create second pollution to environment. If we can apply rubber high elasticity material property to combine with concrete to get high ductility rubber concrete so we can reduce the waste rubber treat problem. In this study we developed a laboratory test for normal, rubber and sandwich complex section test samples. Applied the MTS test system to RC slab by dynamic loading to understand the real behavior of different material sections.

From the test results we can found the full section 5% rubber concrete will increase the ductility and the energy absorbing capacity will increase over 80%. In the sandwich section test results the 5% rubber concrete complex section will improve the energy absorbing and peak strength of the normal RC slab.

KEYWORDS: Rubber Concrete, RC Slab, Dynamic Loading

1. INTRODUCTION (11pt, bold, capital)

Many research discus about the rubber concrete and RC slab dynamic response. Brownjohn et al. (2008) used numerical method to analysis step loading response to high and low frequency slabs. They used the test results to find the slab frequency to root mean square (RMS) of velocity coefficient. El-Dardiry et al. (2007) used elastic modulus transfer method to find the complex steel structure with concrete slab neutral axial offset effect to the slab Eigen frequency. Pan et al. (2008) used human walking loading numerical model to long span slab and get good correlation with field measure results. Pavic, A. et al. (2007) calculated the slab response by autospectral densities (ASDs) and immediate calculation of frequency response functions (FRFs) method to define building floor in shaker loading. Reda Taha et al. (2008) used impact and fracture toughness test to chipped and crumbed rubber concrete to found the rubber concrete properties. They found the brittle behavior of concrete will decrease by increasing the rubber weight replacement ratio. 50% rubber replacement ratio will get optimal response in the impact energy test result. Reynolds, P. (2000) used dynamic loading response spectrum concept to setup frequency response function, (FRF) coefficient to analysis long span concrete floor. Reynolds, P., and Pavic (2003) applied FRF concept to analysis long span RC floor before and after decay behavior. They found the damping will increase 89% after floor decay. Setareh, M. (2010) applied nonstructural elements concept and modal assurance criterion (MAC) matrix to slab dynamic analysis and applied to cantilever slab response. Tsay, R.J. et al. (2010) found in 5% rubber concrete admixture ratio will get optimal material bending strength. Tsay, R.J. et al. (2011) applied the rubber concrete to RC slab and measured the response of pedestrian loading by microtremor. We found the RC slab response by will concentrate to unit Eigen frequency in different loading weight.

The above studied may be research in the material properties of rubber concrete or normal concrete RC slab response. The above papers little discusses about the decay behavior of rubber concrete in dynamic loading. In this study we want to found the ultimate behavior for rubber concrete RC slab by laboratory test. The full section and sandwich section RC slabs will be tested MTS dynamic loading.

2. RUBBER CONCRETE MATERIAL PROPERTIES

We applied 2 case rubber replacement ratios to found the difference between normal concrete. Concrete mix proportions were present as Table 1. The normal concrete design strength is $f_c' = 210 kg/cm^2$.

Table 1. Rubber concrete mix proportion

Sample No.	Water (Kg)	Cement (Kg)	Stone (Kg)	Sand (Kg)	Rubber (Kg)
Ru_PC (0%)	6.15	9.6	30.78	23.01	0
Ru_PC (2.5%)	6.15	9.6	30.78	22.435	0.575
Ru_PC (5%)	6.15	9.6	30.78	21.86	1.150

3. RUBBER CONCRETE RC SLAB LABORATORY TEST

3.1 Test samples setup

The test RC slab samples scale were $200cm \times 80cm \times 12cm$. The slab steel rebar were double layer 2 direction by #4 steel as Fig. 1 shown. In order to understand the behavior in different section layout we designed full and sandwich section as Fig. 2. The sandwich section RC slab combined 7cm normal concrete and 5cm rubber concrete. Detail RC slab section scales were shown in table 2.

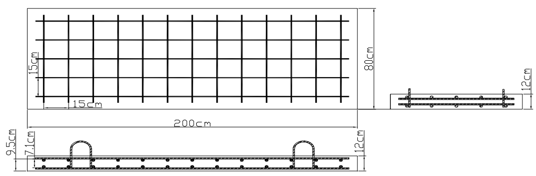
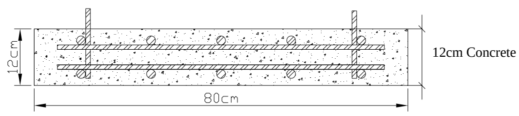
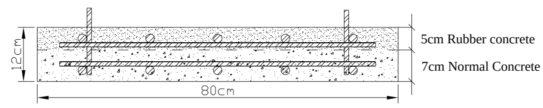


Fig. 1 RC slab test sample scale



(a) Full RC slab



(b) Sandwich RC slab

Fig. 2 Full and sandwich RC slab samples profile section

Table 2. Rubber concrete mix proportion

Sample No.	Rubber concrete replacement ratio	Normal concrete depth (cm)	Rubber concrete depth (cm)
Ru_PC A(0-5%)	0_5%	7	5
Ru_PC	0_2.5%	7	5

B(0-2.5%)			
Ru_PC C(0%)	0	12	0
Ru_PC D(2.5%)	2.5%	0	12
Ru_PC E(5%)	5%	0	12

3.2 MTS System setup.

(a) MTS system setup

MTS system capacity applied to the test is 50t. Maximum displacement for the accelerator is 15cm. The system and test samples setup outlook were shown in Fig. 3.

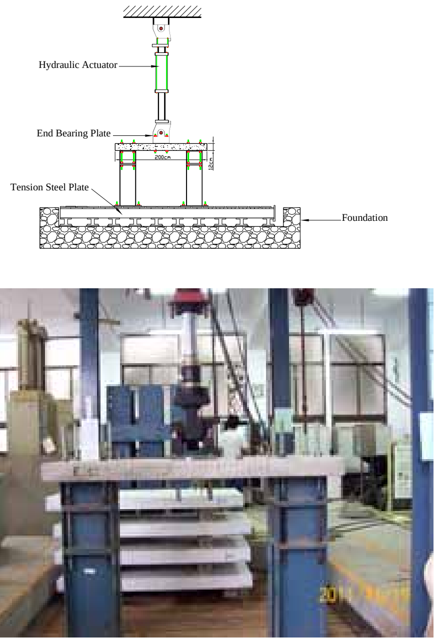


Fig. 3 Sample fix method and MTS test outlook

(b) Displacement control dynamic loading

The dynamic tests were applied by MTS system. We use displacement control method to apply the cycle loading as Fig.4 shown. Every increase step applied 20 cycles loading.

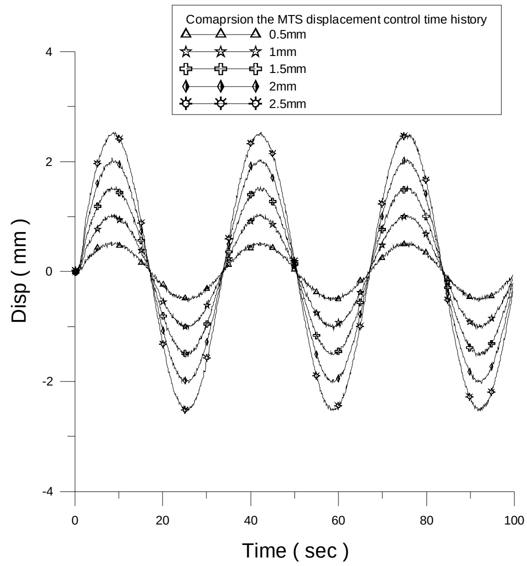


Fig 4. Displacement control MTS dynamic loading time history

3.2 Test results and discussions

(a) Hyperbolic response by dynamic loading

After the dynamic load we can get the hyperbolic curve as Fig. 5 to Fig. 10. The envelopment of hyperbolic curves were present as Fig. 11.

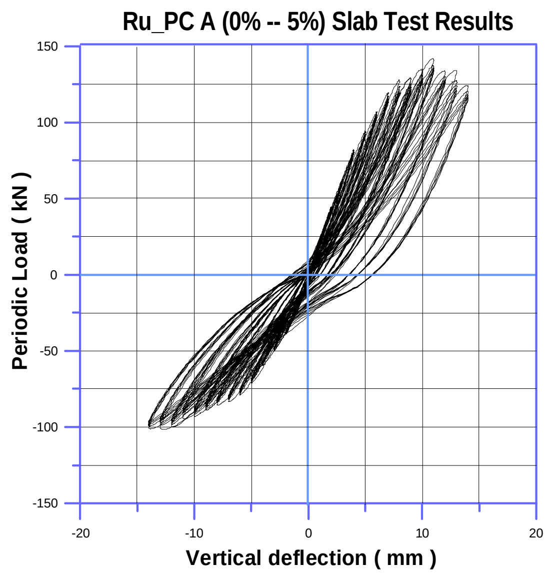


Fig. 5 Sandwich section 5cm 2.5% rubber concrete RC slab dynamic response hyperbolic curve

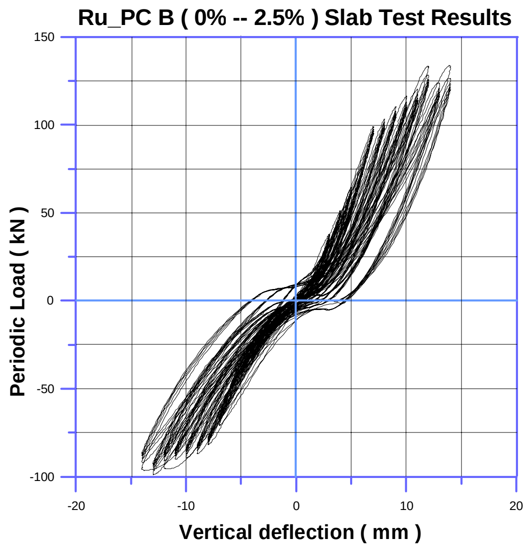


Fig. 7 Sandwich section 5cm 2.5% rubber concrete RC slab dynamic response hyperbolic curve

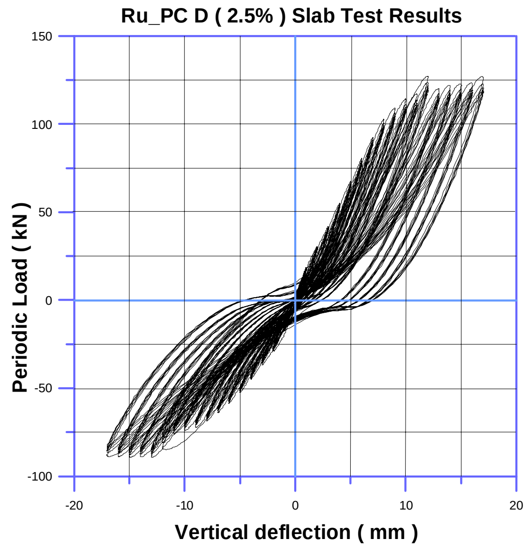


Fig 9. Full section 2.5% rubber concrete RC slab dynamic response hyperbolic curve

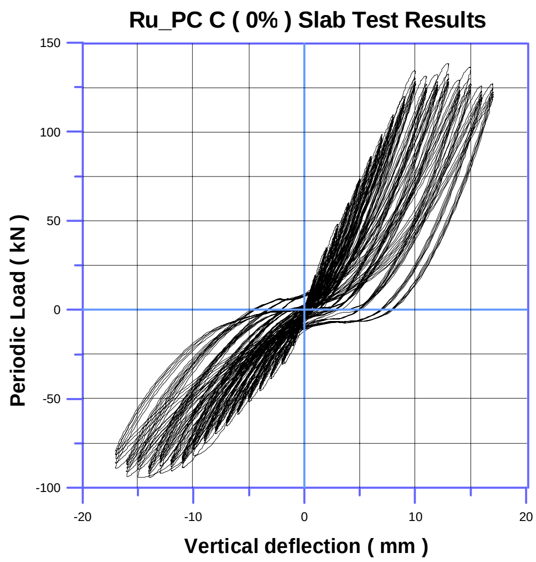


Fig 8. Full section normal concrete RC slab dynamic response hyperbolic curve

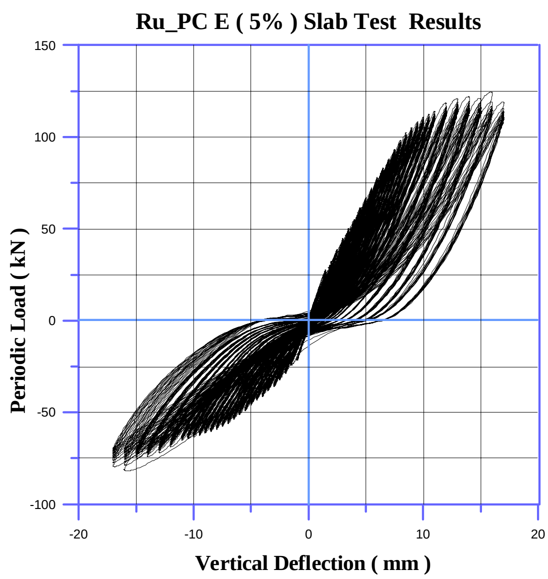


Fig 10. Full section 5% rubber concrete RC slab dynamic response curve

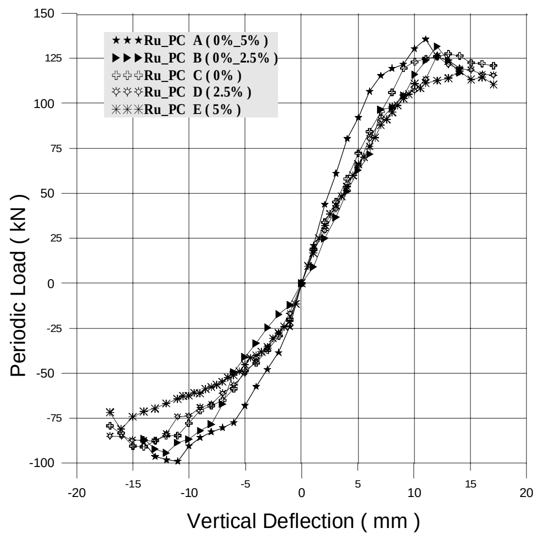


Fig. 11 Envelopment loop curve of different RC slabs

(b) Test result discusions

From Fig. 11 we can get the system energy absoring capacities by calculating the area under hyperbolic curve. Normal concrete RC slab is the minum energy absoring case and the full section 5% rubber cocnrete can absorb maximum energy as Tabel 3 shown. In Table 4 we can found the peak load response we can found the the sandwich section have more stiffness response.

Table 3 Comparison the energy absorbing capacity for different rubber content concrete RC slab

Sample No.	Rubber content ratio	Area under hyperbolic curve (kN-mm)
Ru_PC (0%_5%)	Sandwich section 5cm (5%)	960.1
Ru_PC (0%_2.5%)	Sandwich section 5cm (2.5%)	857.77
Ru_PC (0%)	Full section (0%)	716.5736
Ru_PC (2.5%)	Full section (2.5%)	866.7846
Ru_PC (5%)	Full section (5%)	1295.5524

Table 4 Comparison the ductility response for different rubber content concrete RC slab

Sample No.	Peak load (kN) (A)	Ultimate slab deformation (mm) (B)	A/B
Ru_PC (0%_5%)	135.5994	11.04697	12.2748
Ru_PC (0%_2.5%)	131.6211	12.03101	10.94015
Ru_PC (0%)	127.4428	13.05078	9.765148
Ru_PC (2.5%)	126.3486	12.05594	10.48019
Ru_PC (5%)	117.9335	14.04676	8.39578

When we comapre the different cases energy absorbing and peak load responses we can found the decrease or increase ratio comapare with the normal concrete in Fig. 12 and Fig. 13.

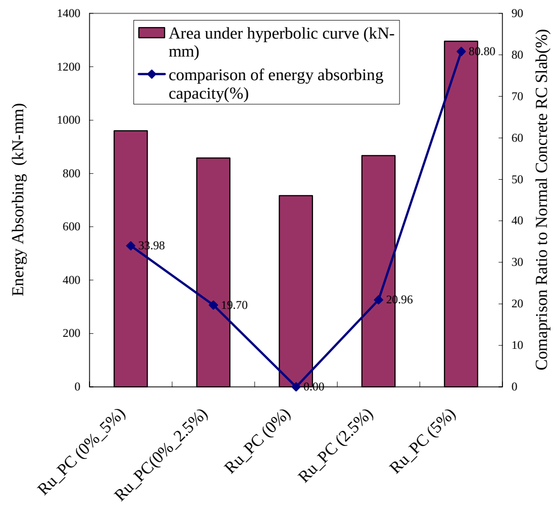


Fig. 12 Comparison the energy absorbing capacity for different RC slab

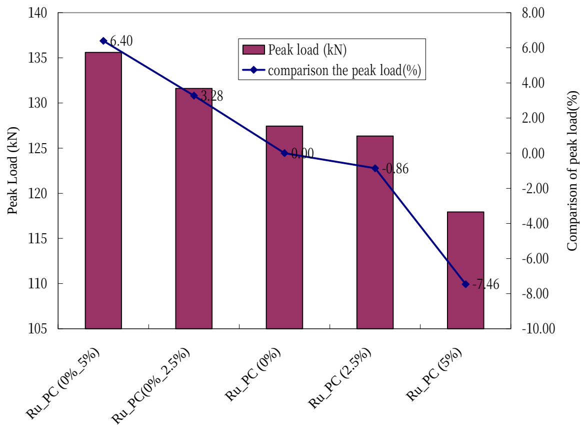


Fig. 13 Comparison the peak load capacity for different RC slab

4. Conclusions and suggestions

From above discussions we can get following conclusions.

1. In the full section case we can found the ductility response for more rubber replacement. The increase ratio is more than 80% than normal concrete RC slab.
2. The sandwich design will effective increase the stiffness and energy absorbing capacities in the test so we suggest the method to decrease the dynamic vibration response on the RC slab.
3. In this paper we found some response of real RC slab in dynamic loading but the theory application and the response in different rubber concrete replace depth response must be studied in the future studies.

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