ASSESSING THE STRENGTH OF REINFORCED CONCRETE BUILDING THROUGH REBOUND HAMMER TECHNIQUE

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Abstract - This paper presents the assessment of the compressive strength for four storeyed reinforced concrete residential building through rebound hammer technique. The relationship between the rebound number and the compressive strength of the concrete for proposed building is done applying linear regression analysis. From the test, we can observe that 46% of the ground floor columns have poor compressive strength less than the design strength 17Mpa while the percentages are lower than 46% for the upper floors. Only 1% of columns possess good concrete compressive strength greater than 35Mpa for all floor levels. Compressive strengths of floor slabs are in fair condition with 70%, 83% and 90 % of slabs are between 17 Mpa and 35Mpa for the three floor levels. For floor beams, about 28% of beams are poor concrete for the first and third floor while 36% for second floor. Overall of that reinforced concrete structure can be categorized as in a fair condition.

Keywords - Assessment, Compressive Strength, Linear Regression Analysis, Rebound Number, Standard Error.

I. INTRODUCTION

The most widely used construction material, concrete, in service is exposed to a wide variety of environments and, because of its physical and chemical nature, may deteriorate as a result. Concrete deterioration typically occurs when the material is exposed to weather, water or chemicals over an extended period of time. When protected from these elements, reinforced concrete can be expected to perform for decades with very little maintenance. However, in many cases, concrete can be exposed to environments that promote deterioration. Once deterioration is apparent, its classification and extent need to be appraised so that appropriate remedial action can be specified. An initial visual inspection of the site can prove valuable in locating deterioration and identification of the distress symptoms. In-situ strength and quality of concrete is required to determine for all structural members. Since extraction of cores is expensive and might weaken the structure, in-situ nondestructive inspection of concrete is advantageous technique. Various nondestructive methods which enable certain properties of concrete to be measured in-situ, from which concrete strength is estimated, have been devised. Of the nondestructive techniques, the rebound hammer technique offers the lowest cost of use and is convenient as well as rapid to employ.

II. CONFIGURATION OF THE BUILDING

The proposed building is a four storeyed reinforced concrete residential building located in Chan Aye Tarzan Township, Mandalay, the Republic of the Union of Myanmar. It was constructed in 1992 and so various deterioration signs are found. Visual inspection was carried out from 16.8.2016 to 25.9.2016. Typical floor plan for proposed building is shown in Fig.1. The beam layout plan and column layout plan are shown in Fig.2 and Fig.3. The beam sizes are 9”x12” for main beams, 9”x9” for secondary beams and 6”x9”for cantilever beams. All columnsare the same size 9”x12” for all stories. The 3D view and left side elevation view for the proposed building are shown in Fig.4 and Fig.5.

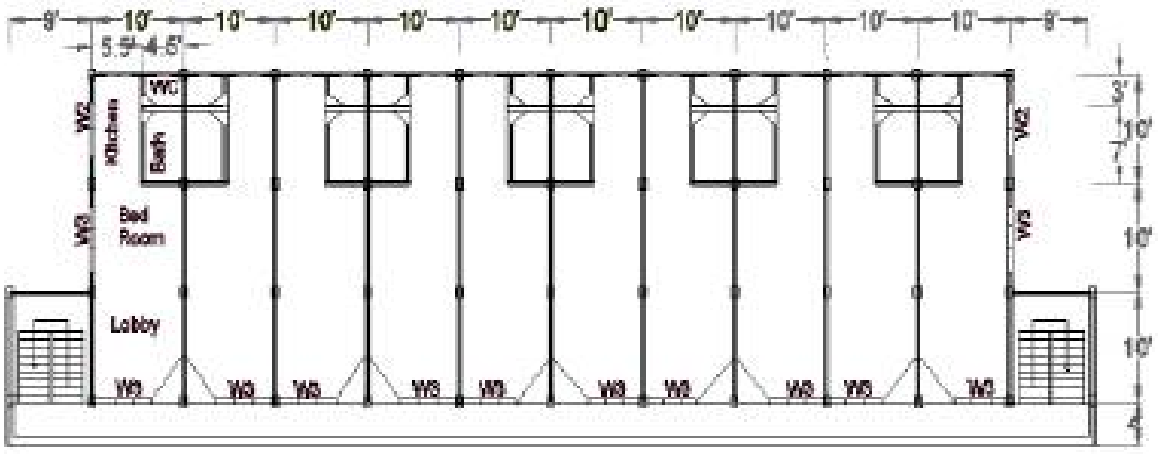


Fig.1.Typical floor plan for proposed building

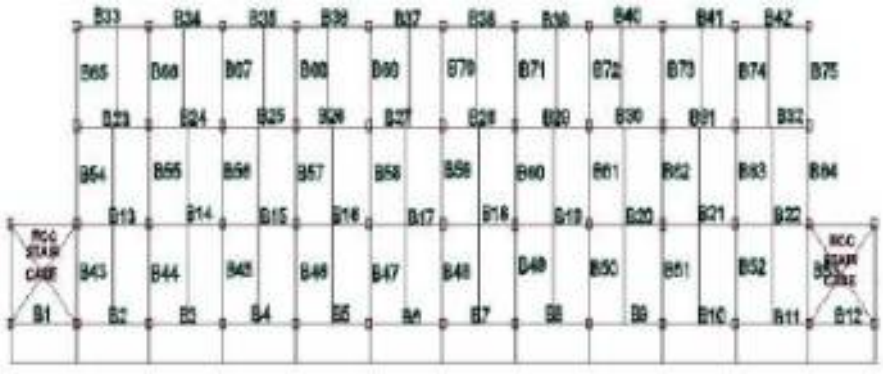


Fig.2.Beam layout plan for the proposed building

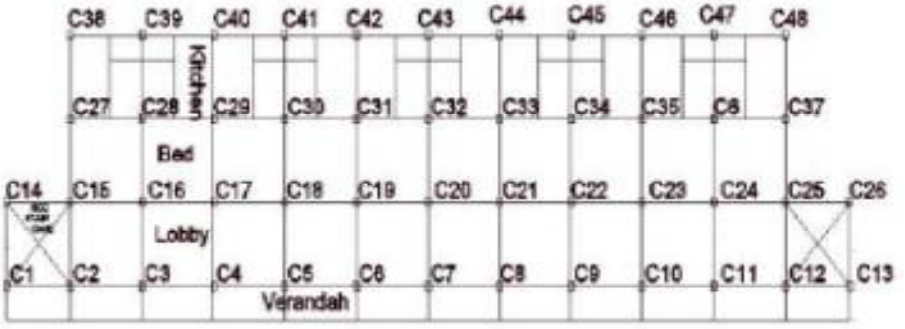


Fig.3.Column layout plan for the proposed building



Fig.4.3D view of the proposed building



Fig.5.Left side elevation of the proposed building

III.REBOUND HAMMER TECHNIQUE

The rebound numbers for the existing members are measured using Schmidt rebound hammer. For columns and beams, the hammer is placed in horizontal position and for all slabs, the equipment is placed in vertical position.The presence of materials in the immediate area where the plunger comes into contact with the concrete will have profound effect. ASTM C805 ststes at least ten readings are taken from each test area and the average value is recorded. Readings differing from the average of the ten readings by more than six units should be discarded. Also, if two readings differ from the average by six units or more, discard the entire set of readings andtake ten new readings within the test area. Concrete can be checked whether the concrete is in good quality or not by using Table 1. The concrete conditions for the proposed building from the rebound number test resultare shown in Table 2.

A Average Rebound Number	Quality of Concrete
▪ 40	Very good hard layer
30 t0 40	Good Layer
20 to 30	Fair
0 to 20	Poor
0	Delaminated

Table 1: Average rebound reading with condition of concrete(BS 1881-202)

Name	Poor Condition	Fair Condition	Good Condition	Total Reading
Slab (1st floor)	-	28 (70%)	12 (30%)	40
Slab (2nd floor)	3 (7%)	33 (83%)	4 (10%)	40
Slab (3rd floor)	4 (10%)	36 (90%)	-	40
Column (Ground)	17 (35)%	30 (63%)	1 (2%)	48
Column (1st floor)	5 (10%)	42 (88%)	1 (2%)	48
Column (2nd floor)	6 (13%)	41 (85%)	1 (2%)	48
Column (3rd floor)	2 (4%)	44 (92%)	1 (2%)	48
Beam (1st floor)	8 (20%)	23 (58%)	9 (22)%	40
Beam (2nd floor)	7 (18%)	33 (82%)	-	40
Beam (3rdfloor)	5 (13%)	35 (87%)	-	40

Table 2: Concrete quality for the Proposed Building

IV. CORRELATION BETWEEN REBOUNDNUMBERAND CONCRETE COMPRESSIVE STRENGTH

Concrete specimens with water-cement ratios (w/c) 0.66, 0.63, 0.56, 0.49, 0.44, 0.39, 0.32 and 0.27 are prepared to obtain various strengths. Materials used for making specimen include ordinary Portland cement, river sand, coarse aggregate (CA) of 20 mm grain size and water as same as the building was constructed. Concrete cylinders (150mm x300mm) and are tested to obtain the compressive strength and concrete cubes (300mmx300mm) are tested by rebound hammer to obtain rebound numbers. The design slump of the concrete is between 75 to 100 mm. The concrete mix proportions for each water cement ratios are shown in Table 3. After approximately 24 hours, the molds are removed and all concrete cylinders and cubes were cured in water and tested at ages 28 days. Three specimens for each water cement ratio are tested and the average value is taken.

Grade (Mpa)	Mix	W/C	Cement (Kg)	Sand (Kg)	Aggregate (Kg)	Water (Kg)
G10	1:2:5	0.66	316.95	622.68	1212.61	219.4
G15	1:2:4	0.63	330.61	630.10	1211.98	219.4
G20	1:2:4	0.56	373.54	607.44	1179.54	219.1
G25	1:1.7:3	0.49	427.00	591.00	1152.00	219.0
G30	1:1.5:3	0.44	475.42	577.10	1124.26	218.7
G35	1:1.3:2.4	0.387	540.50	557.00	1088.60	218.3
G40	1:1:2	0.316	661.97	524.15	1021.25	217.7
G45	1:1:1.5	0.274	763.45	494.72	963.80	217.1

Table 3:Concrete MixProportions

The correlation betweenrebound index and the strength of concrete for the proposed building is done

by using linear regression analysis. The calibration curve of the rebound number and compression strength of concrete for floor slab is shown in Fig.6. The calibration curve of the rebound number and compression strength of concrete for column and beam member is shown in Fig.7. The best fit line which represents the relationship between the rebound number and the compressive strength for floor slab is a straight line which has the following equation;

$$fc(R) = 2.232R - 33.254 \quad (1)$$

The best fit line which represents the relationship between the rebound number and the compressive strength of concrete for column/beam is a straight line which has the following equation;

$$fc(R) = 2.165R - 27.921 \quad (2)$$

Where, f_c = concrete compressive strength
R = rebound number

The number of data sets used for the correlation between the rebound number and concrete compressive strength is n=8.The R^2 value for correlation between concrete strength and rebound number is 97.1%, which indicates a significant correlation. The estimated standard errors are S.E = 2.081 for all cases as shown in Table 4.

The compressive strengths of the members, columns, floor beams and slabs for the proposed building are estimated using (1) and (2). The estimated compressive strengths for floor slabs are shown in Fig.8 to Fig.10. The compressive strength are greater than the design strength 17 Mpa for about 70% and over of the floor slabs in all three floor levels.Fig.11 to Fig.14 show the compressive strengths for columns.

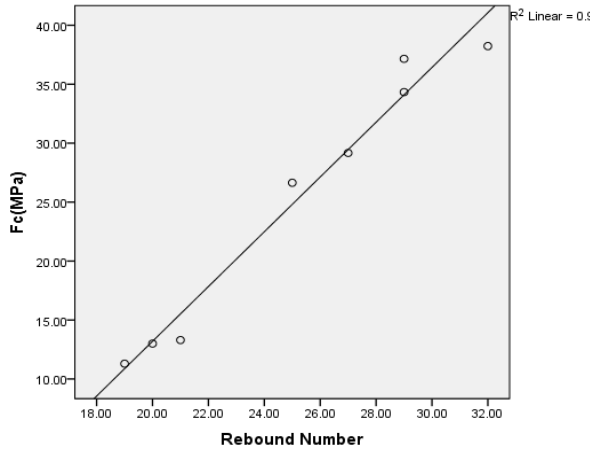


Fig.6. Rebound number /compression strength calibration curve (slab)

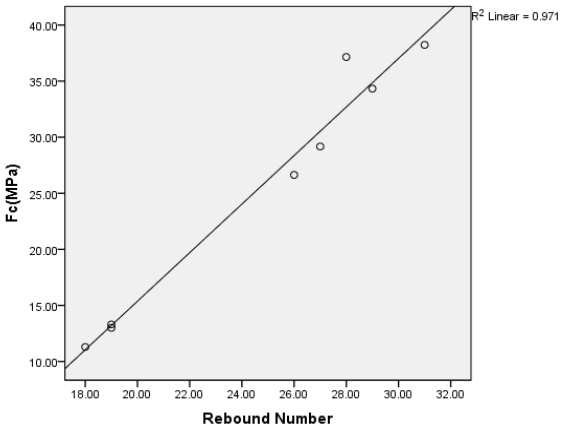


Fig.7. Rebound number /compression strength calibration curve (column/beam)

Table4:Model Summary for Fig.8. and Fig.9

R = sample correlation coefficient, SE= standard error

Figure	R	R^2	Adj R^2	SE
Fig.8	0.985	0.971	0.966	2.081
Fig.9	0.985	0.971	.966	2.081

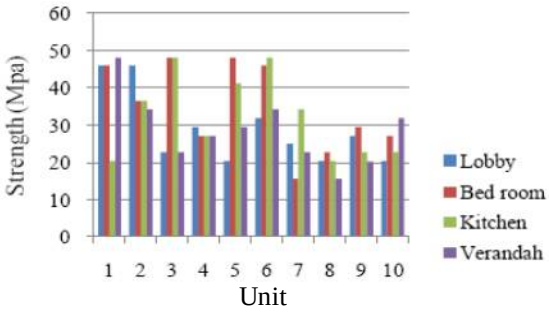


Fig.8.Concrete compressive strength for 1st floor slab

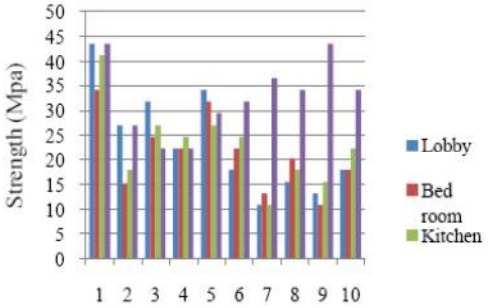


Fig.9.concrete compressive strength for 2nd floor slab

Unit

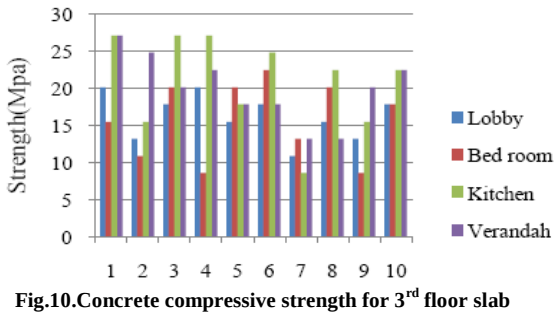
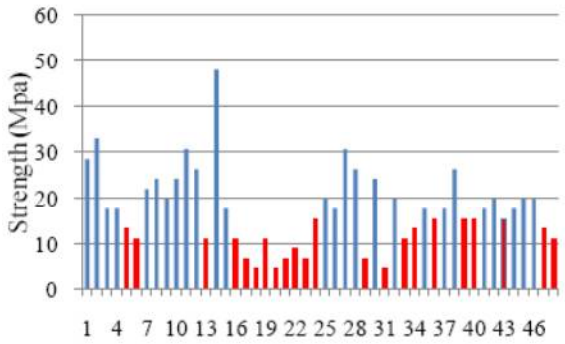
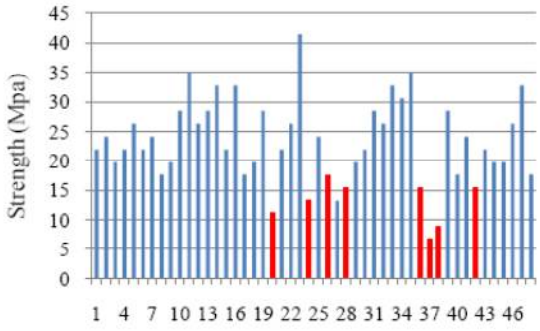


Fig.10.Concrete compressive strength for 3rd floor slab



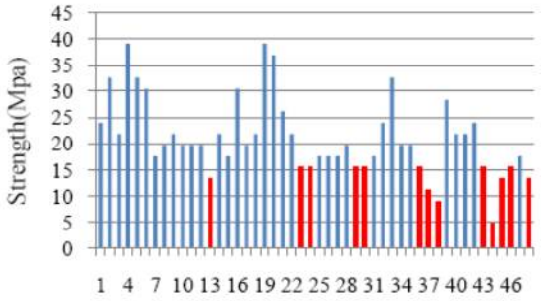
Column

Fig.11.Concrete compressive strength for columns (groundfloor)



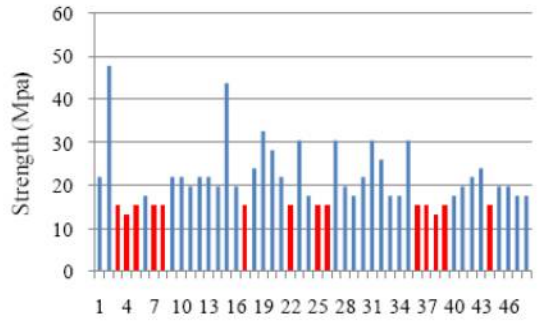
Column

F ig.12.Concrete compressive strength for columns (1st floor)



Column

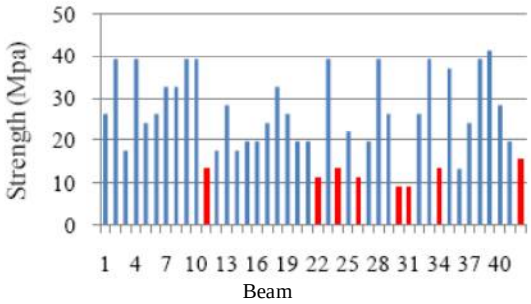
Fig.13.Concrete compressive strength for columns (2ndfloor)



Column

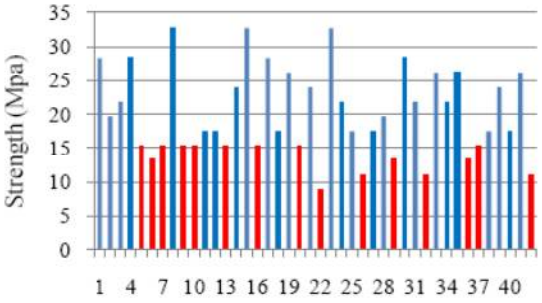
Fig.14.Concrete compressive strength for columns (3rd floor)

Colums with compressive strengths less than the design strength 17Mpa are shown in the red colour. The compressive strengths for 45% of columns in the ground floor are under the design strength 17Mpa.The percentage of columns with compressive strength less than the design strength decreases to 20% for second floor and 30% for the third floor as in Fig.12 to Fig.13.



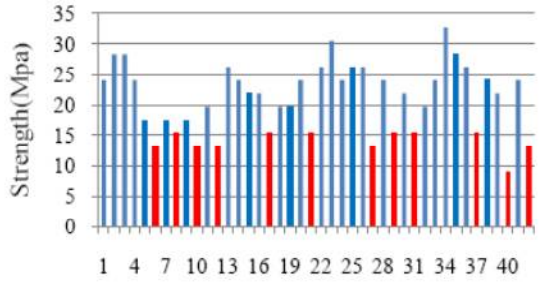
Beam

Fig.15.Concrete compressive strength for beams (1st floor)



Beam

Fig.16.Concrete compressive strength for beams (2ndfloor)



Beam

Fig.17.Concrete compressive strength for beams (3rd floor)

Estimated compressive strengths for floor beams in the longitudinal direction for three floor levels are shown in Fig. 15 to Fig.17.The beams with compressive strengths less than the design strength 17 Mpa are shown in the red colour.The percentage of the floor beams with compressive strength less than the design strengthis lower than 30% for the first and third floor. For the second floor, it increases to about 36%.

CONCLUSIONS

This paper describes assessing the strength of four storeyed reinforced concrete residential building through rebound hammer technique. This building is located in Chan Aye Tarzan Township, Mandalay, Myanmar. Since the life of the building is 25 years, various deterioration signs are found. For a deteriorated reinforced concrete structure, it is

necessary to test the strength of in-situ concrete to know the extent of repair and to choose the effective repair method. For the proposed building, compressive strengths are too weak for most of the interior columns on ground floor. For columns, the compressive strengths increase from the ground floor to third floor while the strengths of the floor slabs decrease from the first floor to third floor

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