CENTRE FOR ARCHITECTURAL RESEARCH & DESIGN
ARCHITECTURE ○ LANDSCAPE ○ INTERIORS

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20th October 2010.

To
Smt.Leela Samson,
Director,
Kalakshetra foundation,
Chennai -6000041.

Dear Smt Leela Samson,
Please find 2 sets Civil tech report for your records.

Sub: "Koothambalam"(Non destructive tests)

S.No.	Description	Issued date	Count
1	Civil tech report	20.10.'10	2Sets.

Thanking you,
With best regards,

J. Ra. Jayakumar
for Ravi Niilakantan. (J.Ra.Jayakumar)

Encl. As above.

26/10/10 AO

DIRECTOR 29/10

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DISCLAIMER

The authors of this report are in no way responsible for the drawbacks that may occur in the assessed structure with time, and depending on the environment to which the structure may be exposed, and also safety of men and public at large, who use the structure. This report containing assessment of portions of the auditorium is made based on limited data obtained by carrying out Non- destructive tests on randomly selected members systematically.

for **CHENNAI CIVIL-TECH RESEARCH FOUNDATION** Pvt. Ltd.

(A.V. Balachandra)
Executive Director

(Hanif Mohammed)
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Assessment of the Condition of Randomly Selected RCC Members of the Traditional Auditorium (Koothambalam Theatre) Kalakshetra Campus, by Non-Destructive Tests

Oct 2010

J.O. No. 1795

Report for:

The Director
Ms. Leela Samson
Kalakshetra Foundation
Chennai.

Through : Centre for Architectural Research & Design, Chennai.

Project :

Traditional Auditorium (Koothambalam Theatre) of Kalakshetra Campus, Chennai.

ACKNOWLEDGEMENT

The authors of this report wish to thank the authorities of M/s. Kalakshetra Foundations Chennai, for sponsoring this work to our organization. The authors wish to thank Ms.Leela Samson, Director, M/s. Kalakshetra Foundations, and Sri, Ravi Neelakantan, Architect, M/s. Centre for Architectural Research & Design, Chennai, Sri. R.V. Narendran, M/s Krithi Consultants, and Jayakumar, Site-Incharge for providing all the facilities at the site, during our investigation work.

for **CHENNAI CIVIL-TECH RESEARCH FOUNDATION** Pvt. Ltd.

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CONTENTS

Assessment of the Condition of Randomly Selected RCC Members of the Traditional Auditorium (Koothambalam Theatre) Kalakshetra Campus, by Non-Destructive Tests

A INTRODUCTION

The authorities of Kalakshetra are re-modeling the auditorium to increase the seating capacity. The traditional auditorium is called "Koothambalam Theatre" .The theatre is in the shape of a polygon (eight sides) with one of the two directly opposite sides used for entry, and the other for the dais / stage for use by the artists. It was informed that this theatre was constructed during 1984 – 1985, and was opened for activities in 1985. The authorities in consultation with architect / consultant wanted the assessment of the condition of the r.c.c structural members that supports the upper gallery portion and roof structure of the theatre, beams and slab portions of the projected slab at higher level for further seating for the audience, by using Non-Destructive (ND) tests. This exercise was taken up to ensure that the r.c.c structural elements are in good condition, as the structure is located in the close proximity of the sea. In connection with this M/s. Chennai Civil-Tech Research Foundation Pvt. Ltd., Velachery, Chennai, was requested to carryout Rebound Hammer Test (RHT), and Ultrasonic Pulse Velocity Test (UPVT), and assess the condition of the randomly selected RCC members of the structure, with regard to cover concrete integrity, and the integrity in the interior portions of the concrete. This report highlights the Non-Destructive tests carried out in, testing methodology, results of ND tests, and conclusions based on the test results.

B SCOPE OF WORK

- Conducting Rebound Hammer tests (RHT) on randomly selected Columns (Upper and Lower levels), Beams & Slab portions
- Conducting Ultrasonic Pulse Velocity tests (UPVT) on ;
  Randomly selected Columns (Upper and Lower levels), Beams & Slab portions, and

Submitting detailed report with Conclusions based on Non-Destructive test results.

C. LIMITATIONS

The assessment of the members/components of the buildings was made, depending on the accessibility of portions for carrying out ND tests, and the sampling of members, after discussions.

D DESCRIPTION OF THE STRUCTURE

The Traditional Theatre, as already explained, is in the form of a polygon (8 sides) in plan. The two directly opposite sides have been used for entry and locating dais. Typical plan, with identification grids are given in Fig.1. There are six (vide plan) inner and outer columns located at the modes of the polygon. The spacing between inner and outer columns is 3405 mm c/c. The beams connecting the inner and outer columns also support the front overhang portion of the slab. The existing theatre is being re-modeled to increase the seating capacity.

This report highlights ND Testing methodologies, results of tests, and conclusions drawn from the test results.

E VISUAL OBSERVATIONS

The condition of the columns, beams and slab portions in general appear to be good, without any distress. Hence the columns, beams and slab portions were selected at random.

F CONDITION ASSESSMENT METHODOLOGY

The condition of the identified r.c.c. structural members of the building by systematic inspection and testing was carried out and the procedure consisted of the following steps:

STEP I

Identification of the members of the building, and make detailed visual observation of the portions of the building.

STEP II

Planning for ND tests : Rebound Hammer Test (RHT) and Ultrasonic Pulse Velocity Test (UPVT)

- Grid points (300mm X 300mm in either direction) on the surfaces of the columns/beams/slab portions were marked, and later cleaned to remove cement laitance

- Rebound hammer test (RHT) was conducted over each grid point, and the readings (as RH. values 'RHV's) were recorded in a specially prepared format for making the analysis.

- The same grid points were used to carry out UPV test, as the grid points were marked as mirror images on opposite sides, if accessible. The readings taken over grid points by TICO TESTER instrument (Velocity in km/s) was recorded in a specially prepared format for making the analysis.

STEP III

Preparation of detailed report, from the analysed test results of different types of tests (NDT) carried out on the structural members.

G NON-DESTRUCTIVE TESTS

In order to systematically document all the results of different tests with respect to structural members of the building, the columns and beams were given identification numbers. The designation for the columns and beams assigned in the building for testing is given in the Table below: (vide also Fig.1 plan of the Koothambalam Theatre).

Table showing ID of members tested

Location	Columns	Beams	Slab Portions of Balcony underside
Lower level	A1, A3, A5, B6, B10 &B13	A2-A3, A4-A5, A3-A4, B4-B5, B7-B8 & B13-B14	--
Upper level	A2, A3 & A5	--	S2, S2, S3, S4, S5, S6, S7, S8, S9, S10

G.1 REBOUND HAMMER TEST (RHT)

Rebound Hammer Test is a quick method of assessing the quality of concrete based on surface hardness indicated by the Rebound Number (also Rebound Hammer value-RHV). If the strength of concrete is high, then the rebound number/value is also high. However, it needs to be ascertained that the surface is not carbonated. Carbonated surfaces also give high Rebound Numbers/values.

Rebound hammers are available with different impact energy. The lowest energy rebound hammer (0.07 kgm) is being used for testing light weight concrete, the medium energy (0.09 kgm) is being used for normal weight concrete, and the highest impact energy (3.0 kgm) is used for testing concrete pavements / runways, etc., where normally higher size aggregates are used in the concrete. Though the working principle of the instrument is same for all types of rebound hammers, facilities for recording of RH values are provided in some of the types. The RH value can be directly read on a calibrated scale provided in the Center of the Hammer. Calibration Tables / Graphs are available with each type of Hammer, to estimate the compressive strength from the RH value, depending on the angle made by the axis of the hammer with the surface. The working principle of the Rebound hammer is very simple. When a spring loaded weight with a shaft is pressed against the concrete surface from its initial protruded position (rider reading `Zero' on the scale provided on the hammer), the weight falls on the surface and rebounds carrying a rider along with it over the calibrated scale depending on the surface strength. The rider position is read, to record the Rebound Hammer Number/Value (RHV).

G.1 (i) *Method of Testing*

In order to assess the quality of concrete in the identified portions of R.C.C. members, first, the area is marked by vertical and horizontal grid lines spaced at 250-300 mm centers. It is to be noted that before fixing the spacing of grid point for each of the identified members, random testing was carried out to ascertain whether any excess variation in Rebound Hammer Value (RHV) and Ultrasonic Pulse Velocity Value (UPV) existed due to non-uniformity of concrete. As these preliminary tests indicated very little variation, uniform grid spacing was chosen. The grid lines were numbered. The same grid points were also used, later, for further NDT tests. The grid points were cleaned by a Carborundum Stone to remove dust, paint, and laitance. In some places plaster did not have good bond, and hence removed and test was carried out. The rebound hammer calibrated earlier in the laboratory was used for the determination of RH values over the grid points marked on the members. Rebound Hammer Test was conducted at each of the grid point in and around 5 places and the average was obtained and recorded. The average value of RHV determined at each grid point on either side of the member was also determined. The test procedure specified in ASTM C805-85/BIS: 13311 (Part-2) was followed.

G1 (ii) *Limitations*

Although the rebound hammer provides a quick and inexpensive method of testing, it has limitations, which are to be recognised before hand. The main factors that affect the readings are:

- Size and age of concrete
- Surface texture
- Concrete mix characteristics
- Stress state and temperature, and
- Carbonated concrete, and moisture content

It is to be noted that the rebound values reflect the concrete quality upto a depth of 50-60 mm, from the surface of the member. In any practical situation, it is very likely that a strength prediction can be made to accuracy better than ± 25%. The calibration scale also suggests that even if a strength prediction is not required, a considerable variation of RHV can be expected even for `identical' concrete, depending on the operation, and hence expectable limits must be determined and conclusions arrived at in conjunction with results of other form of testing.

G.1 (iii) *Test Data Presentation*

Normally, to assess the quality/ condition of concrete in the cover region, the member is marked with grid points with spacing between 200-300 mm c/c in either direction on both the sides of the member depending on the dimensions of the member, and accessibility, so that each point has a mirror reflection on both the sides of the member. The horizontal lines (rows) are marked 1,2,3,4..etc. and vertical lines A,B,C,...... so as to locate grid points 1A, 2A ..... 1B, 2B, 1C, 2C,... and so on. At these points, 3 to 5 readings are taken in and around the grid point and average is determined and recorded as the RHV (Rebound Hammer Value).

It is to be noted that all the members identified for assessment had been plastered. Hence, wherever there was firm plaster with good integrity, readings were taken. In order to assess concrete quality in the core of the member, sufficient readings were taken to make an assessment.

It is to be noted that RHT is to be carried out on concrete surface and not on the plastered surface. In this investigation, since plaster had very good bond with the concrete surface, the readings were taken over the plastered surface, and suitable correction was effected in the readings. The correction factor was determined by taking large number of readings on plastered and surfaces without plaster of different columns in the buildings/blocks. It is also to be noted that the Rebound Hammer Value (RHV) determined is effective from 50-60 mm from the surface, and assuming average plaster thickness of 20mm, the RHV's can still indicate the status of the concrete in the cover region of the R.C.C. members. Considering this aspect, the readings obtained are corrected, and the results of RH test are analysed and interpreted.

Rebound Hammer Test was carried out on all the r.c.c. columns, beams and slab portions (balcony) that were identified by marking a uniform grid of 0.30m x 0.30m in either direction on the surfaces to assess the quality of in-situ concrete and very approximate strength (Reference chart "RH value versus Compressive strength" developed by testing large number of specimens in the laboratory) by measuring surface hardness. RHT was carried out at each grid point using PROCEQ N-type hammer, as per the guidelines of Indian Standard code of practice IS: 13311 (Part II) – 1992, and Rebound Hammer values were recorded in a separate data sheet, and later analysed. Fig.2 shows the instrument, and Figs 3-5 show RHT in progress on the identified structural members of the Theatre.

G.1 (iv) Results of RHT

The results of the RHT for identified members are given in Table-I. The readings of RHV's have been analysed statistically for each r.c.c. member. The 95% Confidence Limit range of RHV's evaluated are used to determine the approximate insitu compressive strength range. The integrity of concrete in the cover region and estimated compressive strength of the members tested is given in Table II (Abstract).The quality grading made is based on reference chart. This chart is given in Table – III.

G. 1 (v) Conclusions from RHT Results

The following conclusions are drawn from RHT results (vide Abstract Table – II)

- The columns selected at random at the lower level and tested indicate presence of good hard layer in the cover concrete region with good integrity. The plaster has adhered to the concrete surface well. The approximate insitu compressive strength is in the range of 33-35 N/mm^2.

- The columns selected at random at upper level and tested indicate presence of very good hard layer (in the cover concrete region) with good integrity. The approximate insitu compressive strength is assessed to be in the range of 38-40 N/mm^2.

- The identified beams at the lower level indicate presence of good hard layer of concrete (cover concrete region) with good integrity and the approximate insitu compressive strength is assessed to be in the range of 35-36 N/mm^2.

The identified portions of the slab indicate presence of fairly good layer of cover concrete with good integrity and the approximate insitu compressive strength is assessed to be in the range of 32-24 N/mm^2.

The RHT versus compressive strength gives approximate strength only (Vide large scatter in the calibration graph-(Fig.6).

H. ULTRASONIC PULSE VELOCITY TEST

Ultrasonic Pulse velocity test using ultrasonic tester (in this case, TICO ULTRASONIC TESTER, (Fig.7) gives information on the integrity of concrete in the interior portions of concrete in the member. Presence of cracks, voids and other imperfections, changes in the structure of concrete, that occur with time, and the present quality of the concrete in relation to standard requirements could be determined from this test. Values of elastic modulus of concrete can also be determined by using the UPV values. In the present investigation, this test was conducted to determine the delamination zones of cover concrete, and voids/cracks in the interior of concrete, if any, etc.

H. (i) ***Principle of the test***

When an impulse is applied to a solid mass, ultrasonic waves are generated. The longitudinal waves with particle displacement in the direction of travel are the most important, as these are the fastest and provide useful information about the medium. If the travel time of these waves is measured, as they pass through the medium, knowing the path length of the medium, longitudinal wave velocity could be calculated. Depending on the ultrasonic pulse/wave velocity (normally expressed in m/sec or km/sec), the homogeneity or compactness of material, presence of voids, etc. could be determined. However, calibrated data on particular type of concrete as used in the structure are necessary. In the absence of such data, test is conducted in the reliable and good portions of the structure with shortest path length, and these values are taken as the reference value.

The ultrasonic scanning test consists of transmitting the ultrasonic pulse waves through the concrete using a transducer connected to the time measuring instrument, and received by a receiver, also connected to the instrument. The time taken by the wave is measured by the instrument `PUNDIT' (Portable Ultrasonic Non Destructive Indicating Tester). Knowing the path length "L" and the time taken for the pulse wave to travel, "T", the pulse velocity (UPV) is calculated, and is usually expressed in km/sec. As already discussed, the UPV value depends on the continuity / integrity of concrete. These can be expressed in qualitative terms by suitable calibration on standard specimens of different strengths of concrete. The UPV values can indicate presence of voids, de-lamination zones and cavities depending on the condition of the medium. ASTM: C597and BIS: 113311 (Part 1) have standardized this method of test.

There are three methods by which the ultrasonic scanning of the member can be carried out depending on the accessibility of sides and arrangement of transmitting and receiving probes (vide Fig.8).

H. (ii) ***Direct method***

This method will give maximum sensitivity and provide a well-defined path length. This method is adopted when the opposite sides of a member/structure is available for scanning. The grid points at same spacing are marked on the two opposite sites, so that they are located at the same line/level. The time taken for the ultrasonic pulse between two points (transit time), and the path length are measured. UPV is calculated.

H. (iii) ***Semi-direct method***

Some times it may be required to examine the concrete by using diagonal paths, it is here semi-direct method is suitable. In foundations, where top and sides are accessible, this method is adopted.

H. (iv) ***Indirect method***

The indirect method is useful, when the opposite surfaces of member/structure are not accessible. Although this method is not as efficient as direct method, it can provide information on de-lamination zones, crack depths, and condition of concrete.

H. (v) ***Limitations***

The least reliable application of this method is for estimation of strength of concrete. Although many factors have influence, while calibrating the instrument, and while using on the structure, it can provide an easy qualitative assessment, when number of points on a structure are scanned. Normally, when the co-efficient of variation of test results is equal to or less than 2.5% on an individual member, it can be assessed as a construction having uniform quality of concrete. When this test is combined with a limited number of tests on `cores' drilled from structural members, a more reliable estimation of its strength is possible. However, from corrosion of reinforcement point of view, electrochemical parameters play very important role.

The same grid points marked for RH tests were used for carrying out Ultrasonic Scanning. Since direct scanning method is efficient, and wherever possible this method was adopted in for assessing the members of the structures, referred to in this investigation. TICO ULTRASONIC TESTER was used in this investigation. It is to be noted here that direct method of scanning gives the best result to assess the interior portions of the concrete. This method was used for portions of the beams and columns of the structure, wherever it was accessible.

Normally, in r.c.c.members, when the ultrasonic pulses travel through the reinforcement, or through the reinforcement intercepting the pulse path, the velocity calculated by usual method (distance / time) needs correction. The correction factor influence will be high in heavily reinforced concrete members. However, in this investigation wherever abnormally high values are determined, readings have been corrected for reinforcement by multiplying the velocity by a factor 0.985. In this investigation direct method was used in columns and beams.

H. (vi) METHODOLOGY

The points marked on the opposite surfaces earlier to line and level, for RH Test was used for this test also. Figures 9-11 show UPVT being conducted on the columns and beams. In this case also, the readings were taken over the plaster, and wherever delamination was observed, plaster was removed, and readings were taken. The difference in velocity with plaster and without plaster was very less due to good adhesion of plaster.

H. (vii) Results of UPVT

The ultrasonic pulse velocity test results for r.c.c members recorded is presented systematically in Table- IV. The results have been statistically analysed and the conclusions have been drawn based on the analysed test results. 95% Confidence Limit Range of pulse velocity obtained for r.c.c. members in the building have been summarized in Table – V (Abstract). The quality integrity grading made is based on a reference chart. This chart is given in Table – VI.

H. (viii) Conclusions from UPVT Results

It is observed from the UPV test results that the columns and beams have concrete integrity as follows (ref. Table – V). It can be seen from the abstract that;

The lower and upper columns (six columns at lower level and identified at three columns at upper level) identified at random and tested have concrete quality, "Medium to Good" and "Good" respetively. This grading is acceptable considering that the concrete was hand mixed. The plaster has adhered well to the concrete surface.

❖ All the beams identified and tested also indicate quality grading range of "Medium to Good". This grading is acceptable, for the same reason mentioned above.

I. OVERALL CONCLUSIONS FROM ND TESTS

The randomly selected and identified columns, beams and slab portions indicate presence of reasonably Fair-Good hard cover concrete layer with Medium – Good integrity. The interior portions also indicate Medium-Good integrity. This quality grading is acceptable. Considering the accuracy of interpretation of strength from Rebound values to be $\pm$ 20%, the lower bound

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approximate value of insitu compressive strength range in columns, beams and slab portions can be taken as 28-30 N/mm^2.

It can be concluded from the limited test results that the integrity of concrete (cover concrete and interior portions) and strength are satisfactory. However, the strength parameters acceptability for the anticipated loads need to be checked by the structural Consultant / Architect.

for **CHENNAI CIVIL-TECH RESEARCH FOUNDATION** Pvt. Ltd.

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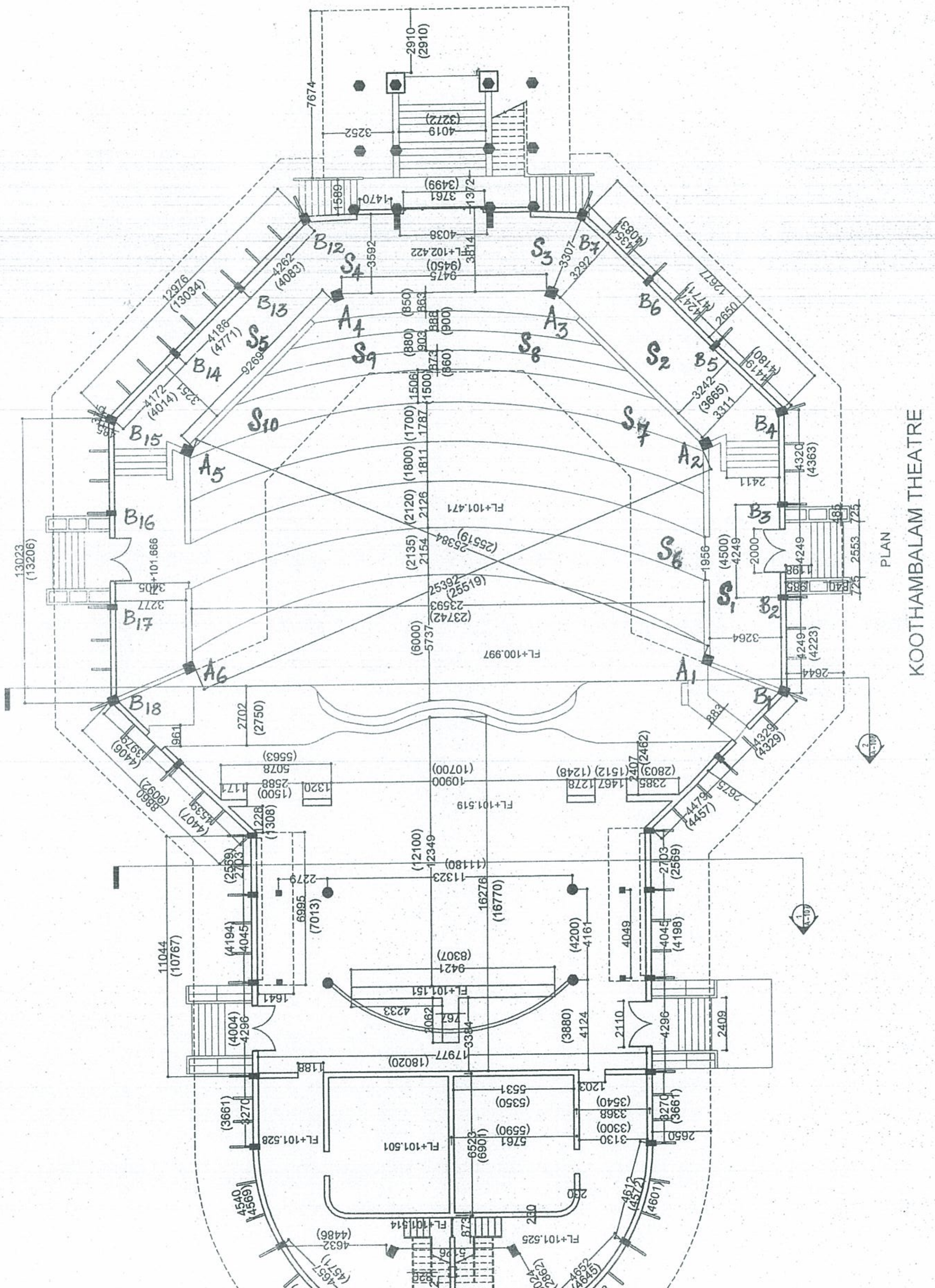
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Fig.1

CCTRF

PHOTOGRAPHIC DOCUMENTATION

General View of the Building

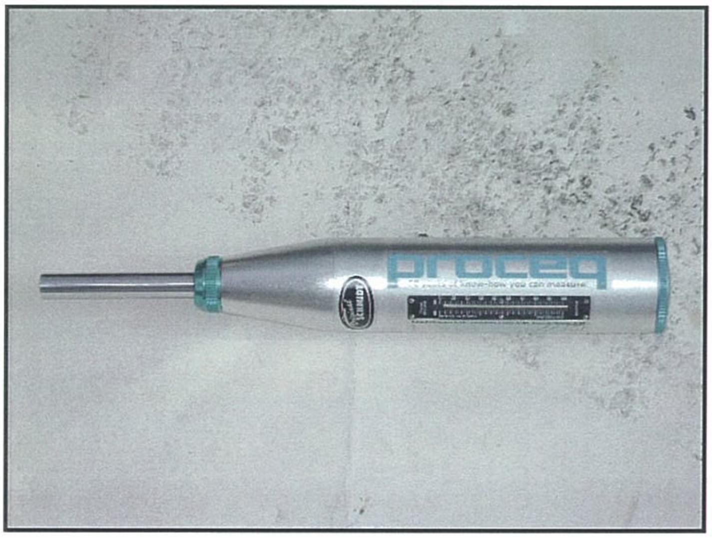

Fig.2 Rebound Hammer Instrument

CCTRF

Fig. 3

Fig. 4

Fig. 5

Fig. 3 – 5 Rebound Hammer Tests in Progress

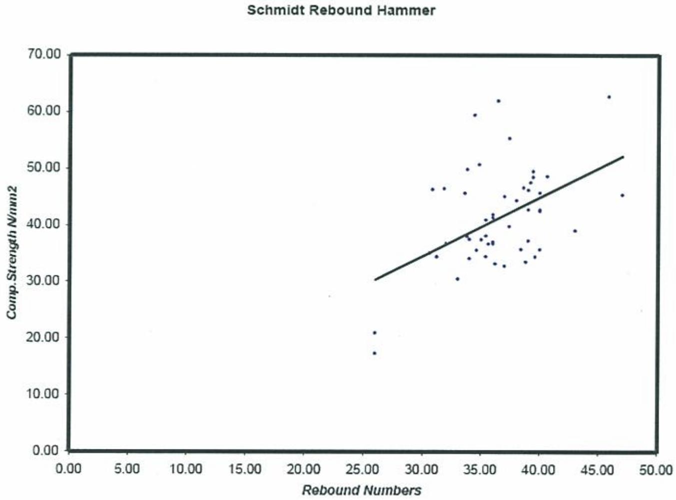

Fig. 6 – Calibration Graph

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Fig. 7 Ultrasonic Tester

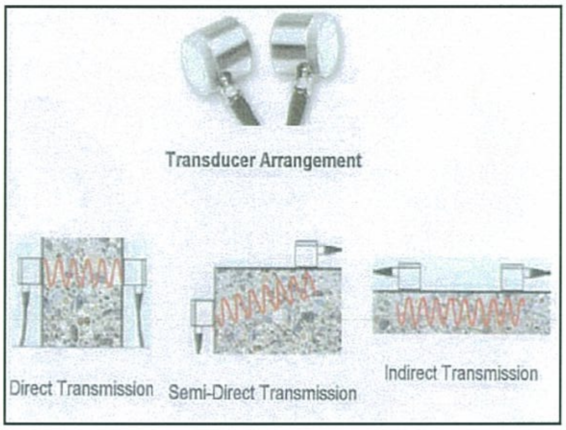

Fig. 8 Probe arrangement

Fig. 9

Fig. 10

Fig. 11

Fig. 9 – 11 UPV Test in progress

Table - I

RHT Readings - Column

Client / Project : Kalashetra Building@Besant Nagar
Concrete member : Column
Grid / Size : A3 / 425 x 425mm

	East		West		North		South	
	A	B	A	B	A	B	A	B
1	36	36	28	34	40	38	40	40
	36	34	30	30	40	36	38	30
	40	32	36	34	38	34	32	34
2	52	38	40	38	30	42	38	36
	38	38	36	34	38	38	36	38
	36	44	36	36	40	44	38	38
3	38	44	36	40	40	38	28	40
	46	48	32	32	40	36	36	38
	44	44	28	34	38	38	38	36
4	46	46	38	36	34	36	36	32
	48	46	36	36	30	32	42	38
	46	44	40	42	34	34	32	28

N	96
Max	52
Min	28
Average	37
SD	4.82
COV(%)	12.88
95%CLR	38
	36

Concrete member : Column
Grid / Size : A1 / 425 x 425mm

S.No	East		West		North		South	
	A	B	A	B	A	B	A	B
1	30	36	32	38	30	34	32	28
	36	30	36	26	30	36	30	30
	34	32	34	32	32	30	32	30
2	28	36	36	30	30	28	34	32
	30	34	32	38	32	30	32	28
	34	32	32	32	38	30	34	34
3	28	30	30	30	38	30	32	32
	26	30	32	32	34	32	34	28
	32	32	34	34	28	34	32	28
4	30	32	28	26	34	32	32	30
	28	30	24	24	38	34	30	34
	34	30	28	28	40	34	30	36
5	30	28	36	38	30	30	30	28
	34	28	32	40	28	32	32	28
	28	26	34	30	30	34	34	30
6	28	28	34	36	42	32	28	32
	30	30	32	34	28	30	26	32
	30	28	34	38	30	30	30	36
7	32	28	34	32	28	32	32	34
	36	26	28	32	30	34	32	36
	30	26	30	30	32	34	32	32

N	168
Max	42
Min	24
Average	32
SD	3.21
COV(%)	10.17
95%CLR	32
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Page - 1

Concrete member : Column
Grid / Size : A5 / 420 x 420 mm

	East		West		North		South	
	A	B	A	B	A	B	A	B
1	46	44	42	38	44	50	46	38
	50	42	46	30	46	48	44	42
	58	40	34	42	44	58	40	48
2	46	52	42	48	48	52	48	48
	40	50	40	44	50	48	40	54
	44	44	52	34	54	46	46	44
3	50	44	44	46	46	54	48	44
	46	46	40	44	58	56	48	52
	54	48	46	46	42	50	54	42
4	40	40	40	50	42	58	52	42
	54	44	44	54	58	52	46	52
	44	46	42	44	42	50	44	46

N	96
Max	58
Min	30
Average	46
SD	5.54
COV(%)	11.96
95%CLR	47
	45

Concrete member : Column
Grid / Size : B13 / 430 x 255 mm

S.No	East		West		North		South
	A	B	A	B	A	B	A
1	32	38	40	38	Not Accessible		40
	38	42	30	36			40
	40	44	32	40			34
2	42	46	42	34			44
	40	48	30	36			40
	42	44	32	36			36
3	38	38	40	44			48
	38	42	40	40			42
	36	34	38	42			40
4	42	44	40	32			42
	40	46	32	22			44
	44	44	34	32			50
5	40	36	30	32			30
	38	36	36	38			32
	36	42	38	36			30
6	48	38	30	38			42
	44	40	34	38			32
	40	34	44	38			32
7	44	44	34	34			50
	42	42	44	38			50
	44	42	46	34			48
8	34	42	34	40			36
	40	36	42	36			42
	46	40	44	38			46

N	120
Max	50
Min	22
Average	39
SD	5.15
COV(%)	13.20
95%CLR	40
	38

Table - I
RHT Readings - Column

Concrete member : Column
Grid / Size : B10 / 430 x 250 mm

S.No	East A	East B	West A	West B	North A	North B	South A
1	50	44	40	44	Not Accessible		46
	54	60	44	40			54
	52	44	54	40			52
2	54	54	44	48			46
	56	42	50	58			44
	60	50	56	40			42
3	50	50	54	52			52
	54	48	48	54			52
	50	48	58	52			50
4	52	60	56	46			54
	54	50	54	42			46
	54	42	44	48			48
5	44	46	48	50			50
	48	46	52	50			62
	42	44	52	52			44
6	48	46	48	44			50
	44	46	46	54			52
	42	44	50	48			52
7	50	42	50	48			60
	46	40	48	46			62
	42	44	52	52			54

N	105
Max	62
Min	40
Average	49
SD	5.26
COV(%)	10.70
95%CLR	50
	48

Concrete member : Column
Grid / Size : B6 / 425 x 250 mm

S.No	East A	East B	West A	West B	North A	North B	South A
1	44	44	44	42	Not Accessible		50
	50	40	46	44			36
	32	46	44	38			52
2	42	32	40	38			44
	50	42	30	32			36
	38	44	44	34			32
3	42	48	44	38			42
	40	40	48	44			50
	46	44	46	40			46
4	38	44	50	44			32
	40	44	46	50			46
	38	34	38	48			44
5	36	40	46	44			46
	42	44	50	50			38
	40	46	42	40			44
6	44	38	32	42			32
	40	32	48	38			44
	46	48	36	40			40
7	42	44	44	52			34
	46	42	42	54			36
	36	40	42	42			34

N	105
Max	54
Min	30
Average	42
SD	5.32
COV(%)	12.69
95%CLR	43
	41

Concrete member / Location : Column / Upper Level
Grid / Size : A2 / 415 x 425 mm

S.No	East A	East B	West A	West B	North A	North B	South A	South B
1	32	42	42	44	38	46	44	48
	40	38	46	52	44	36	46	48
	44	48	44	54	34	38	40	40
2	42	46	42	42	34	44	42	40
	44	40	44	46	36	36	46	46
	44	52	42	44	46	36	46	46
3	40	46	40	44	32	36	38	42
	42	40	40	52	38	36	50	44
	46	52	42	42	34	34	42	42
4	50	44	42	46	36	30	44	44
	42	52	48	40	40	40	42	42
	42	42	50	38	46	34	40	42

N	96
Max	54
Min	30
Average	42.33
SD	4.94
COV(%)	11.67
95%CLR	43
	41

Concrete member / Location : Column / Upper Level
Grid / Size : A3 / 415 x 425 mm

S.No	East A	East B	West A	West B	North A	North B	South A	South B
1	42	44	44	52	40	30	40	50
	50	48	48	38	44	34	42	54
	60	48	54	32	44	40	46	42
2	48	54	32	48	40	34	62	44
	60	54	44	54	38	34	64	44
	60	42	46	46	36	46	60	62
3	44	44	42	38	38	42	50	60
	48	46	44	40	38	38	42	52
	44	54	48	38	40	40	44	60
4	50	42	50	44	36	32	40	54
	46	44	46	46	32	36	54	50
	44	46	48	46	38	42	56	60

N	96
Max	64
Min	30
Average	45.56
SD	7.80
COV(%)	17.12
95%CLR	47
	44

Concrete member / Location : Column / Upper Level
Grid / Size : A5 / 430 x 415 mm

S.No	East A	East B	West A	West B	North A	North B	South A	South B
1	42	38	58	54	52	54	42	42
	44	40	42	54	48	44	40	42
	42	52	44	60	48	48	48	40
2	44	52	52	48	44	54	38	40
	44	52	52	60	46	55	36	40
	52	50	48	50	48	44	44	42
3	48	42	50	46	44	50	38	42
	44	52	50	48	42	46	34	42
	50	50	42	46	46	46	40	38
4	38	42	52	46	48	48	44	44
	36	48	56	46	46	46	34	40
	40	40	42	52	48	48	38	40

N	96
Max	60
Min	34
Average	45.74
SD	5.62
COV(%)	12.28
95%CLR	47
	45

Table - I

RHT Readings - Beam

Client / Project : Kalashetra Building@Besant Nagar
Concrete member : Beam
Grid : A4 - A5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
North West	34	36	34	32	32	30	40	38	32	36	44	32	34	44	34	50	46	44	N	216
	32	30	36	38	36	32	36	32	34	44	46	36	34	38	36	50	42	42	Max	52
	34	32	42	38	32	34	36	34	24	24	48	34	32	32	42	40	44	42	Min	24
	30	36	32	38	32	42	34	32	28	34	32	34	36	36	36	34	40	50	Average	36
	32	38	36	36	30	40	32	32	36	34	38	32	40	38	38	36	40	42	SD	4.73
	38	32	38	32	36	44	38	34	44	32	36	34	40	38	36	40	38	52	COV(%)	13.25
South East	30	30	32	32	32	34	34	36	42	38	28	34	38	32	32	36	34	32	95%CLR	36
	32	30	34	34	30	40	32	40	34	40	32	36	36	34	30	34	32	34		35
	34	30	32	36	30	30	38	42	40	38	32	36	38	38	30	30	34	36		
	32	32	34	32	32	30	40	44	38	40	40	36	34	36	32	34	30	32		
	36	34	36	34	34	32	36	46	48	30	38	34	38	30	34	32	32	40		
	32	36	30	32	36	32	30	36	44	40	30	36	32	38	34	36	32	42		

Concrete member : Beam
Grid : A3 - A4

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
North	32	40	34	30	30	36	36	44	32	40	42	38	40	48	42	34	36	34	N	216
	32	30	30	30	32	34	32	28	44	38	46	50	44	42	34	36	40	36	Max	54
	30	32	40	32	30	30	38	44	38	32	46	46	46	42	44	36	44	40	Min	24
	32	36	46	32	28	36	40	40	40	38	40	44	48	32	54	50	50	50	Average	37
	34	32	38	40	38	32	38	40	42	30	42	38	48	40	54	34	34	54	SD	6.02
	30	30	30	48	40	32	36	36	34	50	30	32	32	40	32	34	50	42	COV(%)	16.40
South	44	30	34	34	28	36	32	28	34	30	30	36	42	36	38	34	54	38	95%CLR	38
	36	36	24	36	34	34	36	26	30	34	36	38	38	38	32	36	38	44		36
	28	30	36	32	36	34	34	32	36	28	40	32	36	40	36	42	52	38		
	36	32	32	36	30	36	34	34	28	30	30	36	36	38	40	44	40	32		
	30	34	34	36	32	34	36	30	36	32	34	34	40	36	38	48	42	30		
	34	30	36	28	36	36	32	34	38	38	30	34	44	32	32	48	42	40		

(14)

Table - I

RHT Readings - Beam

Concrete member : Beam

Grid : A2 - A3

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
North West	22	32	36	36	34	36	30	34	30	34	38	38	34	44	32	36	34	36	**N**	**216**
	36	40	34	40	32	34	32	32	28	36	36	30	38	34	38	40	36	38	**Max**	**48**
	30	34	32	42	36	30	34	34	38	40	32	32	36	32	34	34	32	34	**Min**	**22**
	32	40	30	30	34	36	36	34	40	32	34	34	40	36	36	44	38	30	**Average**	**34**
	32	42	32	30	36	24	38	36	42	44	32	36	40	38	32	32	30	34	**SD**	**4.15**
	34	42	32	30	36	30	32	34	40	48	34	34	38	34	34	38	36	36	**COV(%)**	**12.12**
South East	38	40	40	32	26	34	28	32	32	34	30	36	30	30	42	32	30	38	**95%CLR**	**35**
	38	30	44	34	30	38	28	30	30	38	32	32	32	34	44	34	30	30		**34**
	40	34	34	36	32	30	30	36	30	32	28	34	34	32	30	40	32	34		
	42	36	36	44	34	34	30	28	34	34	28	32	32	32	32	39	32	32		
	38	38	36	36	36	28	28	26	36	32	30	30	38	40	32	28	34	38		
	32	40	40	28	30	32	32	30	32	36	34	30	32	40	30	38	32	32		

Concrete member : Beam

Grid / Size : B4 - B5 / 270 x 160mm

	1	2	3	4	5	6	7	8	9	10	11	12	13		
East	52	52	46	34	30	46	42	38	32	40	44	44	40	**N**	**78**
	58	48	38	46	32	44	46	42	48	36	42	42	44	**Max**	**58**
	56	42	56	36	44	42	48	48	46	34	46	40	48	**Min**	**30**
West	38	46	40	36	40	48	42	46	54	36	48	46	44	**Average**	**43**
	48	52	36	38	34	34	48	46	50	48	44	42	48	**SD**	**6.03**
	32	44	44	38	34	42	44	48	38	46	42	48	46	**COV(%)**	**13.96**
														95%CLR	**45**
															42

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Table - I

RHT Readings - Beam

Concrete member : Beam
Grid : B7 - B8

	1	2	3	4	5	6	7	8	9	10	11	12	13		
East	44	40	46	46	42	38	34	44	44	44	36	44	38	N	78
	46	42	42	48	44	38	44	40	38	42	44	38	38	Max	52
	40	44	48	50	40	42	42	48	46	46	42	42	34	Min	30
West	38	40	40	44	36	42	46	36	40	38	36	46	42	Average	41
	42	34	38	38	44	38	40	38	36	30	48	42	44	SD	4.54
	36	32	34	50	48	52	46	38	38	34	38	40	40	COV(%)	11.04
														95%CLR	42
															40

Concrete member : Beam
Grid : B13 - B14

	1	2	3	4	5	6	7	8	9	10	11	12	13		
East	42	36	36	38	40	32	32	36	32	38	34	34	34	N	78
	44	34	36	36	36	34	34	30	36	34	32	32	36	Max	48
	46	42	30	36	34	36	34	36	38	34	36	36	34	Min	30
West	36	36	32	34	32	38	32	48	34	36	44	42	38	Average	36
	34	34	34	32	30	34	34	40	38	42	46	44	42	SD	4.12
	38	30	32	30	34	36	34	38	36	40	40	40	44	COV(%)	11.36
														95%CLR	37
															35

Concrete member : Beam
Grid : A2 - A3

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
North West	22	32	36	36	34	36	30	34	30	34	38	38	34	44	32	36	34	36	N	216
	36	40	34	40	32	34	32	32	28	36	36	30	38	34	38	40	36	38	Max	48
	30	34	32	42	36	30	34	34	38	40	32	32	36	32	34	34	32	34	Min	22
	32	40	30	30	34	36	36	34	40	32	34	34	40	36	36	44	38	30	Average	34
	32	42	32	30	36	24	38	36	42	44	32	36	40	38	32	32	30	34	SD	4.15
	34	42	32	30	36	30	32	34	40	48	34	34	38	34	34	38	36	36	COV(%)	12.12
South East	38	40	40	32	26	34	28	32	32	34	30	36	30	30	42	32	30	38	95%CLR	35
	38	30	44	34	30	38	28	30	30	38	32	32	32	34	44	34	30	30		34
	40	34	34	36	32	30	30	36	30	32	28	34	34	32	30	40	32	34		
	42	36	36	44	34	34	30	28	34	34	28	32	32	32	32	39	32	32		
	38	38	36	36	36	28	28	26	36	32	30	30	38	40	32	28	34	38		
	32	40	40	28	30	32	32	30	32	36	34	30	32	40	30	38	32	32		

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Table - I
RHT Readings - Slab

Client / Project : Kalashetra Building @ Besant Nagar
Concrete member : Slab
Grid / Size : S10 / 1m x 1m

	1	2	3	4	5
A	42	34	40	42	40
	44	34	46	44	42
	46	38	44	46	44
B	42	32	37	40	38
	46	34	38	36	30
	30	36	30	36	36
C	32	44	44	38	40
	34	42	32	34	44
	32	42	36	38	36
D	28	30	34	32	32
	32	36	30	34	22
	30	38	30	32	34
E	38	36	44	30	32
	32	40	34	32	30
	34	42	32	34	34

N	75
Max	46
Min	22
Average	36
SD	5.30
COV(%)	14.56
95%CLR	38
	35

Concrete member : slab
Grid / Size : S9 / 1m x 1m

	1	2	3	4	5
A	40	38	42	42	38
	44	40	40	44	40
	42	36	46	44	44
B	36	36	38	40	44
	38	42	40	38	40
	34	46	40	38	46
C	44	36	38	38	38
	40	36	40	40	40
	40	42	38	36	38
D	38	46	36	54	46
	40	40	38	50	38
	36	40	38	40	42
E	42	46	42	36	40
	38	40	38	38	38
	40	42	38	38	40

N	75
Max	54
Min	34
Average	40
SD	3.49
COV(%)	8.68
95%CLR	41
	39

Concrete member : Slab
Grid / Size : S8 / 1m x 1m

	1	2	3	4	5
A	32	32	32	44	30
	34	34	40	42	32
	36	38	42	30	34
B	30	36	34	32	42
	32	36	32	32	44
	34	32	34	40	40
C	34	32	32	40	44
	36	34	34	40	46
	32	32	34	42	46
D	42	36	42	30	36
	44	40	40	34	38
	46	32	30	36	30
E	34	36	36	30	38
	38	32	30	40	36
	40	32	32	38	38

N	75
Max	46
Min	30
Average	36
SD	4.57
COV(%)	12.67
95%CLR	37
	35

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Table - I
RHT Readings - Slab

Concrete member : Slab
Grid / Size : S7 / 1m x 1m

	1	2	3	4	5		
A	40	38	34	28	28		
	36	34	30	36	32	N	75
	38	30	36	30	30	Max	42
B	28	28	32	30	34	Min	26
	30	30	30	26	28	Average	33
	30	34	34	28	30	SD	3.48
C	32	32	34	30	30	COV(%)	10.58
	36	34	30	38	30	95%CLR	34
	32	28	36	32	34		32
D	34	42	38	36	30		
	36	34	32	36	30		
	38	34	30	32	34		
E	34	36	34	34	38		
	40	34	30	32	36		
	38	36	30	34	28		

Concrete member : Slab
Grid / Size : S6 / 1m x 1m

	1	2	3	4	5		
A	32	34	32	36	32		
	30	34	36	38	34	N	75
	34	32	30	34	30	Max	42
B	36	36	36	40	30	Min	28
	32	30	38	32	34	Average	35
	34	36	30	36	30	SD	3.75
C	42	38	32	38	34	COV(%)	10.83
	32	38	32	38	34	95%CLR	35
	36	34	30	30	28		34
D	38	36	38	36	36		
	30	30	28	30	28		
	34	42	28	38	30		
E	40	36	36	38	38		
	34	38	38	40	40		
	38	42	36	34	42		

Concrete member : Slab
Grid / Size : S5 / 1m x 1m

	1	2	3	4	5		
A	58	50	42	48	52		
	56	50	54	44	50	N	75
	56	52	48	46	48	Max	58
B	52	52	52	52	50	Min	38
	50	42	50	50	48	Average	49
	50	46	54	52	38	SD	4.14
C	54	48	52	52	52	COV(%)	8.50
	44	52	52	46	48	95%CLR	50
	52	46	48	50	50		48
D	44	50	54	44	50		
	52	44	48	46	52		
	50	52	46	50	46		
E	48	50	52	48	40		
	50	54	40	42	48		
	42	50	42	42	44		

Table - I
RHT Readings - Slab

Concrete member : Slab
Grid / Size : S4 / 1m x 1m

	1	2	3	4	5		
A	50	54	52	46	52		
	48	46	48	50	54	N	75
	56	52	44	50	42	Max	56
B	54	54	46	44	52	Min	40
	50	52	40	48	46	Average	48
	52	54	46	50	52	SD	4.22
C	54	48	46	44	50	COV(%)	8.83
	42	54	42	42	52	95%CLR	49
	50	46	52	52	52		47
D	42	40	46	44	42		
	44	44	42	40	44		
	44	42	42	46	48		
E	42	48	50	50	54		
	50	46	50	46	46		
	48	52	46	48	48		

Concrete member : Slab
Grid / Size : S3 / 1m x 1m

	1	2	3	4	5		
A	48	42	40	40	50		
	50	48	46	42	48	N	75
	52	46	50	44	46	Max	58
B	54	52	52	32	50	Min	30
	56	48	38	30	40	Average	47
	52	56	54	56	48	SD	5.45
C	50	52	52	50	46	COV(%)	11.51
	52	56	48	44	46	95%CLR	49
	48	52	38	44	44		46
D	50	46	48	46	42		
	52	50	52	58	52		
	48	46	50	50	52		
E	40	44	40	46	46		
	52	48	54	40	42		
	50	40	44	46	48		

Concrete member : Slab
Grid / Size : S2 / 1m x 1m

	1	2	3	4	5		
A	52	52	46	56	50		
	56	50	58	48	54	N	75
	54	50	40	52	50	Max	58
B	48	58	50	50	40	Min	40
	54	54	48	44	50	Average	52
	50	56	54	46	52	SD	3.81
C	56	52	52	50	56	COV(%)	7.31
	50	54	56	52	54	95%CLR	53
	52	52	56	56	52		51
D	54	52	50	58	44		
	52	54	52	56	52		
	54	56	54	52	48		
E	50	56	56	52	50		
	52	54	54	56	48		
	58	56	52	58	54		

Table - I
RHT Readings - Slab

Concrete member / Location : Slab
Grid / Size : S1/ 1m x 1m

	1	2	3	4	5
A	40	42	44	40	46
	40	44	46	50	52
	42	46	48	52	46
B	50	46	48	46	52
	48	46	50	52	50
	50	48	34	50	56
C	54	54	46	54	54
	52	50	42	54	50
	54	46	40	52	52
D	54	54	56	52	50
	50	58	52	54	54
	54	54	56	50	52
E	52	50	54	48	50
	54	58	54	44	52
	54	52	52	50	54

N	**75**
Max	**58**
Min	**34**
Average	**50**
SD	**4.77**
COV(%)	**9.57**
95%CLR	**51**
	49

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TABLE - II

REBOUND HAMMER TEST - ABSTRACT

S.No	Floor	Identification	95% Confidence range of Rebound Value		95% Confidence range of Rebound Value after applying Correction Factor for orientation and carbonation		Corresponding range of Approx. Compressive Strength (N/sq.mm)	
			Lower	Upper	Lower	Upper	Lower	Upper
COLUMNS								
1	Ground	A3	36	38	31	33	33	35
2	Ground	A1	31	32	26	27	28	29
3	Ground	A5	45	47	40	42	42	44
4	Ground	B13	38	40	33	35	35	37
5	Ground	B10	48	50	43	45	45	47
6	Ground	B6	41	43	36	38	38	40
7	Upper Level	A2	41	43	36	38	38	40
8	Upper Level	A3	44	47	39	42	41	44
9	Upper Level	A5	45	47	40	42	42	44
BEAM								
1	Ground	A4-A5	35	36	30	31	32	33
2	Ground	A3-A4	36	38	31	33	33	35
3	Ground	A2-A3	34	35	29	30	31	32
4	Ground	B4-B5	42	45	37	40	39	42
5	Ground	B7-B8	40	42	35	37	37	39
6	Ground	B13-B14	35	37	30	32	32	34
UPPER LEVEL SLAB								
1	Balcony Floor	S1	49	51	37	39	39	41
2	Balcony Floor	S2	51	53	39	41	41	43
3	Balcony Floor	S3	46	49	34	37	36	39
4	Balcony Floor	S4	47	49	35	37	37	39
5	Balcony Floor	S5	48	50	36	38	38	40
6	Balcony Floor	S6	34	35	22	23	24	25
7	Balcony Floor	S7	32	34	20	22	22	24
8	Balcony Floor	S8	35	37	23	25	25	27
9	Balcony Floor	S9	39	41	27	29	29	31
10	Balcony Floor	S10	35	38	23	26	25	28

for Chennai Civil-Tech Research Foundation Pvt. Ltd.,

(H.G. Sreenath)
Technical Director

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TABLE – III

REFERENCE QUALITY GRADING CHART FOR REBOUND HAMMER

EQUIPMENT	:	SCHMIDT HAMMER
MAKE	:	M/S. PROCEQ, SWITZERLAND
TYPE	:	N-34
MODEL NO.	:	110830
TECHNICAL REFERENCE	:	1. IS: 13311 (Part-2) – 1992 2. Instrument manual furnished by M/s. Proceq, Switzerland.

Average Rebound Number	Estimated Quality Grading Of Concrete
Above 40	Very good hard Layer
30 to 40	Good Layer
20 to 30	Fair
Below 20	Poor concrete

Average Rebound Number	Estimated Compressive Strength Range (N/Sq.mm)
22 to 26	10 to 14
22 to 30	14 to 18
32 to 34	18 to 22
34 to 38	22 to 26
38 to 42	26 to 30
42 to 46	32 to 34

Note : The above quality grading chart is developed based on the calibration chart designed for the above test instrument

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TABLE - IV

UPVT Readings - Column

COLUMN

Client : Kalashetra Building at Besant Nagar

Concrete member : Column

Grid / Size : B13 / 430 x 255 mm

S.No	East-West		N-S		
	A	B	A		
1	3.48	4.40	Not Accessible	N	16
2	3.54	3.44		Max	4.40
3	3.48	3.52		Min	3.28
4	3.42	3.41		Avg	3.57
5	3.62	3.30		SD	0.26
6	3.28	3.46		COV(%)	7.31
7	3.78	3.62		95%CLR	3.70
8	3.65	3.72			3.44

Concrete member : Column

Grid / Size : B10 / 405 x 250mm

S.No	East-West		N-S		
	A	B	A		
1	3.64	3.70	Not Accessible	N	14
2	3.62	3.81		Max	3.88
3	3.54	3.60		Min	3.54
4	3.88	3.84		Avg	3.68
5	3.73	3.77		SD	0.11
6	3.57	3.60		COV(%)	3.03
7	3.56	3.62		95%CLR	3.74
					3.62

Concrete member : Column

Grid / Size : A5 / 430 X 420mm

S.No	East-West		East-West			
	A	B	A	B	N	16
1	3.74	3.61	3.87	3.84	Max	3.87
2	3.60	3.68	3.42	3.62	Min	3.42
3	3.56	3.55	3.50	3.72	Avg	3.63
4	3.60	3.62	3.64	3.48	SD	0.12
					COV(%)	3.35
					95%CLR	3.69
						3.57

Concrete member : Column

Grid / Size : A1 / 415 x 430mm

S.No	East - West		North - South			
	A	B	A	B	N	28
1	3.36	3.44	3.50	3.60	Max	3.80
2	3.65	3.60	3.65	3.58	Min	3.30
3	3.71	3.70	3.70	3.80	Average	3.54
4	3.38	3.30	3.62	3.50	SD	0.13
5	3.40	3.34	3.54	3.56	COV(%)	3.53
6	3.47	3.54	3.50	3.53	95%CLR	3.59
7	3.68	3.42	3.53	3.62		3.50

Concrete member : Column

Grid / Size : A3 / 435 X 425mm

S.No	East-West		North - South			
	A	B	A	B	N	16
1	3.81	3.75	3.75	3.81	Max	3.81
2	3.50	3.46	3.52	3.35	Min	3.35
3	3.46	3.42	3.40	3.48	Avg	3.53
4	3.40	3.38	3.64	3.42	SD	0.16
					COV(%)	4.57
					95%CLR	3.61
						3.46

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TABLE - IV

UPVT Readings - Column

Concrete member : Column
Grid / Size : B6 / 425 x 245mm

S.No	East-West A	East-West B	N-S A
1	3.43	3.46	Not Accessible
2	3.60	3.48	
3	3.53	3.52	
4	3.67	3.61	
5	3.47	3.64	
6	3.56	3.58	
7	3.58	3.52	
8	3.57	3.52	

N	16
Max	3.67
Min	3.43
Avg	3.55
SD	0.07
COV(%)	1.89
95%CLR	3.58
	3.51

Concrete member : Column / Above balcony
Grid / Size : A2 / 420 X 420mm

S.No	East-West A	East-West B	North - South A	North - South B
1	3.48	3.45	3.47	3.48
2	3.64	3.58	3.60	3.66
3	3.83	3.66	3.87	3.93
4	3.66	3.61	3.69	3.70

N	16
Max	3.93
Min	3.45
Avg	3.64
SD	0.14
COV(%)	3.90
95%CLR	3.71
	3.57

Concrete member : Column / Above balcony
Grid / Size : A3 / 420 X 425mm

S.No	East-West A	East-West B	North - South A	North - South B
1	3.42	3.52	N-A	N-A
2	3.60	3.61	3.51	3.37
3	3.64	3.63	3.62	3.44
4	3.72	3.80	3.58	3.62

N	14
Max	3.80
Min	3.37
Avg	3.58
SD	0.12
COV(%)	3.26
95%CLR	3.64
	3.52

Concrete member : Column / Above balcony
Grid / Size : A5 / 410 X 435mm

S.No	East-West A	East-West B	North - South A	North - South B
1	N-A	N-A	3.60	3.42
2	3.63	3.51	3.51	3.51
3	3.45	3.57	3.52	3.49
4	3.62	3.42	3.40	3.57

N	14
Max	3.63
Min	3.40
Avg	3.52
SD	0.08
COV(%)	2.14
95%CLR	3.56
	3.48

TABLE - IV

UPVT Readings - Beam

Client / Project : Kalashetra Building at Besant Nagar
Concrete Member : Beam
Grid / Path Length : A2 - A3 / 440mm

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
A	3.55	3.56	3.84	3.62	3.36	3.24	3.41	3.62	3.44	3.57	3.64	3.48	3.21	3.30	3.24	3.44	3.30	3.37
B	3.86	3.71	3.50	3.84	3.47	3.40	3.74	3.40	3.27	3.86	3.60	3.51	3.42	3.36	3.59	3.39	3.42	3.28

N	36
Max	3.86
Min	3.21
Average	3.49
SD	0.18
COV(%)	5.27
95%CLR	3.55
	3.43

Concrete Member : Beam
Grid / Size / Path Length : A4 btw A5 / 435 mm

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
A	3.77	3.72	3.75	3.35	3.30	3.44	3.61	3.28	3.34	3.28	3.30	3.24	3.18	3.20	3.42	3.44	3.27	3.59
B	3.58	3.44	3.40	3.40	3.28	3.42	3.42	3.34	3.27	3.30	3.16	3.28	3.26	3.45	3.40	3.58	3.65	3.40

N	36
Max	3.77
Min	3.16
Average	3.40
SD	0.16
COV(%)	4.71
95%CLR	3.46
	3.35

Concrete Member : Beam
Grid / Size / Path Length : A3 btw A4 / 435 mm

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
A	3.36	3.38	3.24	3.20	3.28	3.37	3.31	3.24	3.32	3.28	3.30	3.41	3.41	3.26	3.36	3.14	3.34	3.14
B	3.14	3.26	3.18	3.44	3.34	3.29	3.30	3.34	3.56	3.44	3.74	3.50	3.28	3.30	3.24	3.28	3.20	3.22

N	36
Max	3.74
Min	3.14
Average	3.32
SD	0.12
COV(%)	3.65
95%CLR	3.36
	3.28

Concrete Member : Beam
Grid / Path Length : B13 btw B14 / Pl - 270 mm

	1	2	3	4	5	6	7	8	9	10	11
A	3.78	3.51	3.56	3.53	3.48	3.49	3.40	3.48	3.43	3.48	3.42

N	11
Max	3.78
Min	3.40
Average	3.51
SD	0.10
COV(%)	2.93
95%CLR	3.57
	3.44

Concrete Member : Beam
Grid / Path Length : B4 btw B5 / Pl - 275 mm

	1	2	3	4	5	6	7	8	9	10	11
A	3.29	3.44	3.20	3.34	3.36	3.41	3.36	3.40	3.38	3.64	3.41

N	11
Max	3.64
Min	3.20
Average	3.38
SD	0.11
COV(%)	3.18
95%CLR	3.45
	3.32

Concrete Member : Beam
Grid / Path Length : B7 btw B8 / Pl - 270 mm

	1	2	3	4	5	6	7	8	9	10	11
A	3.34	3.40	3.30	3.43	3.40	3.48	3.52	3.40	3.42	3.32	3.34

N	11
Max	3.52
Min	3.30
Average	3.40
SD	0.07
COV(%)	1.99
95%CLR	3.44
	3.36

TABLE V
ABSTRACT OF UPVT

ULTRASONIC PULSE VELOCITY TEST - ABSTRACT

S.No	Floor	Identification	95% ConfidenceRange of Velocity Values km/sec	Concrete Quality Grading
COLUMNS				
1	Ground	A3	3.46-3.61	Medium to Good
2	Ground	A1	3.50-3.59	Good
3	Ground	A5	3.57-3.69	Good
4	Ground	B13	3.44-3.70	Medium to Good
5	Ground	B10	3.62-3.74	Good
6	Ground	B6	3.51-3.58	Good
7	Upper Level	A2	3.57-3.71	Good
8	Upper Level	A3	3.52-3.64	Good
9	Upper Level	A5	3.48-3.56	Medium to Good
BEAM				
1	Ground	A4-A5	3.35.3.46	Medium to Good
2	Ground	A3-A4	3.28-3.36	Medium to Good
3	Ground	A2-A3	3.43-3.55	Medium to Good
4	Ground	B4-B5	3.32-3.45	Medium to Good
5	Ground	B7-B8	3.36-3.44	Medium to Good
6	Ground	B13-B14	3.44-3.57	Medium to Good

for Chennai Civil-Tech Research Foundation Pvt. Ltd.,

(H.G. Sreenath)
Technical Director

Table - VI

REFERENCE QUALITY GRADING BASED
ON ULTRASONIC PULSE VELOCITY TEST

Instrument : PUNDIT [Portable Ultrasonic Non-Destructive Digital Indicating Tester]

Make : PUNDIT- UPV Instrument from M/s. CNS, UK

Pulse Velocity (Km/sec)	**Concrete Quality Grading**
Below 3.0	Doubtful
3.1 to 3.5	Medium
3.6 to 4.5	Good
Above 4.5	Excellent

Note: Concrete quality grading for different velocity criterion as reproduced from Table-2 of IS: 13311(Part I) 1992

In case of "Doubtful quality", it may be necessary to carry out further testing.

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