ISSN No:-2456-2165

Evaluating the Condition of Existing Building for Repairing

Arafat Rehman[1], Dr. M.P. Verma[2]
[1] PhD- Student, [2] Professor
Department of Civil Engineering,
Madhyanchal Professional University, Bhopal, 462001, India

Abstract:- The building structure construction in a period of last 25 years is become enlarge and become more important in development of India and to built infrastructure. Concrete structures construction taken place very rapidly due to the shifting of rural populations to urban areas is mainly due to urban biases in terms of development and economic opportunities. It has been observed in developing countries that urban residents have a better standard of living. In this study we focus on old structure which is constructed before, need special attention for maintenance, repair rehabilitation. The purpose of this Research to understand the important of monitoring the condition of old concrete building, durability and reliability of concrete structures. Therefore, effective methods for evaluating the dilapidated level are required to proposed repair technique. This leads to use combined development of several non destructive test methods. Ultrasonic pulse velocity test over any concrete structure reflects its conditions. Several physical and chemical properties of concrete structures significantly influence the density condition. Rebound hammer test provide compressive strength. Cover meter test provide cover details as well as reinforcements details and all this test combine will determine the present condition of reinforced concrete structures and by optimization and analysis of all these tests jointly would be significant for planning maintenances and replacement of old buildings.

Keywords*:- old Concrete, Dilapidated buildings, evaluation condition, repairing and service life.*

I. INTRODUCTION

In civil structures, Concrete is a foremost and crucial construction material used all around the world. Concrete Building condition Evaluation is a demand of this era as the construction industry is growing and become more important in the situation of the normal environmental process are adversely affected. This research work focuses on present's day evaluation of existing concrete building to do rehabilitation or repair if possible so that concrete building service life can extend. The method use for testing is Non destructive testing (NDT) method for concrete Building. Than the Condition of structure will evaluate the physical as well chemical affect on the condition of concrete structure. The purpose is to understand the use of monitoring the condition of existing building structure. The methodology was based on literature review, review contents from various previous literatures in civil engineering department in India and around the world.

A. FRAMEWORK OF THE STUDY

In the present Study visual inspection (physical survey) of building structure member of different age group will be carried out. Than the concrete cover will be finding out of all selected structures. Than the condition of different structure members will be identify such as column, beam slab etc after physical survey .The age of structure will be consider as a time period after the construction (age of structure). After finding out age the concrete cover will determine of faltering structure members. After this assessing the condition of structures will taken place by Non destructive method (NDT), such as concrete cover test and ultrasonic pulse velocity (UPV) Test and rebound hammer test for assessing the existing condition of concrete structures. Than the concrete structure will be divided into categories. The classification of concrete structure will be as per the dilapidated building condition. Afterword repairing technique will proposed as per condition. For example Minor repairs needed, structure repair needed, partial demolition requiring major structure repairs or to be demolition immediately.

B. REPAIRING

Process of Rehabilitation and repairing of existing building structure. Reconstruction and renewal of the old buildings, either in whole or in part.

C. OBJECTIVE

- Physical survey of structure. (Visual inspection).
- Performing the Non- destructive testing on the structure.
- Classification of building into categories. (D-1,D-2,D-3-,D-4)
- Proposing the treatment and repairing technique for structure maintenance.

II. LITERATURE SURVEY

Various researchers have performed studies to indentify the causes of dilapidated building . Ravi kumar, nandipati s.m., t. barkavi, and c. natarajan. 2019. "structural health monitoring: detection of concrete flaws using ultrasonic pulse velocity." journal of building pathology and rehabilitation 3 (1): 1–9.

Kumar, mahesh, s. kaleem afrough zaidi, s. c. jain, and k. v.s.m. krishna. 2018. "reliability of non-destructive testing methods in the assessment of the strength of concrete columns reinforced with two layers of transverse confining stirrups: empirical evidence." international journal of recent technology and engineering 8 (2): 3450–59.

ISSN No:-2456-2165

Hasbullah, mohd amran, rohana yusof, and mohd nazaruddin yusoff. 2017. “assessing the performance of concrete structure based on the width of the crack using upv.” journal of engineering science and technology 12 (special issue): 17–25.

Sanjeev verma,S bhadauria and Saleem akhtar p. research into the The deterioration of concrete structures in the last few decades calls for effective methods for condition evaluation and maintenance. This resulted in development of several nondestructive testing (NDT) techniques for monitoring civil infrastructures. Hindawi Publishing Corporation Journal of Construction Engineering Volume 2013, Article ID 834572, 11(2013).

Concrete Committee of Japan Society of Civil Engineers, Standard Specifications for Concrete Structures-Maintenance, Guidelines for Concrete, JSCE, Tokyo, 2007. Department RGPV Bhopal (M.P.), Kushvaha Suresh (HOD Civil Engg. Department RGPV Bhopal (M.P.),Hussain Aslam (Asst. Prof. Civil Engg. Department RGPV Bhopal (M.P.).

Abbott, G. R., Mc Duling, J. J., Dr, P. S., & Schoeman, J. C. Building Condition Assessment: A Performance evaluation tool towards sustainable asset management. CIB World Building Congress, 649- 662.(2007) 12. Kempton, J., Alani, A., & Chapman, K. (2001).

III. METHODS AND MATERIALS

It has been absorb from various literatures review that dilapidated building or concrete structure considerably depend on the NDT test value, concrete cover and duration of structure are major factors influencing the service life of concrete structure. The City of Bhopal has been selected for the present study. In the field survey five concrete structures (old buildings) of different age group with structure members like column, slab and beam will be tested by NDT methods and at least five faltering structure members of each structure, will be tested in all five building concrete structure in different localities of Bhopal.evaluation of concrete structure condition will take place. As shown in flow chart below figure.

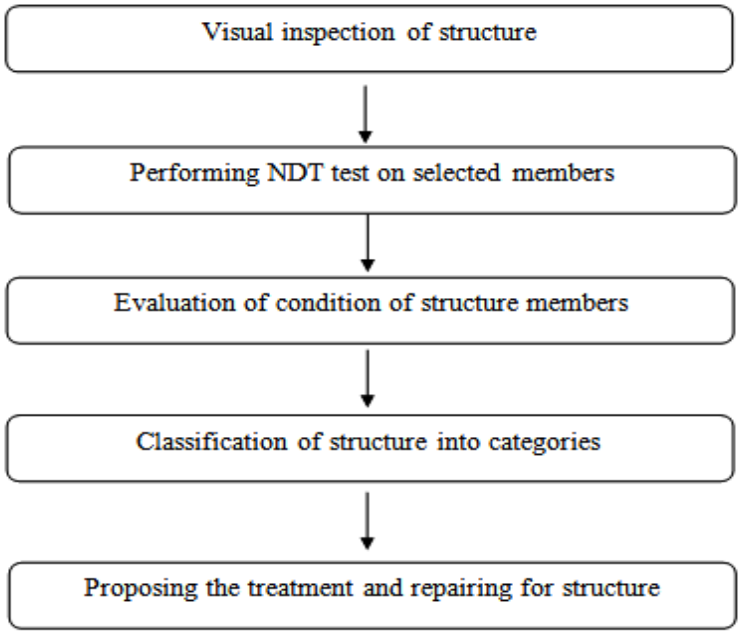

Fig. 1: flow chart

A. *PARAMETERS SELECTED FOR STUDY*

For performing the test in present study following parameters have been selected-

- Age of structure.
- Faltering structure member.
- Concrete cover.
- UPV value.
- Rebound hammer value.
- Repairing of structure

B. *SELECTION OF STRUCTURE*

The selection of structure depends on the condition of structure and it was of great concern for the study. It has been planned to select the structures of different age groups located in residential, commercial and industrial areas in different parts of the Bhopal City. Age perimeter taken was 10 year to 50 year as deterioration of concrete structure during 10-50 years. Apart from age, the condition of structure members as per visual inspection of structure taken into account and also the ease to perform the test on the structure members. As well as the permission of owner/occupants has been required. In order to complete the work in appropriate time and avoid obstruction, it has been targeted to select the structures easy to get permission and

ISSN No:-2456-2165

plan for repair, renovation or plan to for retrofitting in future if possible. Structure selected is as follows-

- Institutional building.
- Hostel building.
- Residential building.
- Residential / Commercial building.
- Ice factory building.

Parameter	Test / Method
A. Concrete	
Strength	Rebound Hammer, Windsor Probe, Ultrasonic Pulse Velocity, CAPO, Core, Pull Off, Break-off
Concrete quality, Homogeneity and Voids	Ultrasonic Pulse Velocity, Pulse Echo, Endoscopy, Gamma Ray Radiography
Damages – Fire/Blast	Rebound Hammer and UPV
Cracks – Pavements/Water Tanks	Ultrasonic Pulse Velocity, Acoustic Crack Detector, Dye Penetration Test, X–Ray Radiography, Gamma Ray Radiography, Thermal Imaging, Crack Scope
B. Steel / Reinforcement	
Location, Cover, Size	Rebar Locator, Bar-size
Corrosion	Half-Cell Potential, Resistivity, Carbonation, Chloride Content
Condition	Endoscope/ Borescope

Table 1: VARIOUS NON-DESTRUCTIVE EVALUATION TECHNIQUES

IV. RESULTS AND DISCUSSION

Visual inspection of old building shows the sign of faltered structure members. Physical analysis of all five structure, information and data collected during the visual inspection critical members and test perform are as follows.

Structure No.	Critical Members	Name of Test
Structure1	Column	Rebound hammer and UPV test
Structure2	Beam	Cover meter and Rebound hammer
Structure3	Column	Cover meter, rebound hammer and UPV test
Structure4	Slab and slab of cantilever.	Cover meter, rebound hammer and UPV test
Structure5	Beam	Cover meter, rebound hammer and UPV test

Table 2: Critical members of all structure

After taking physical analysis of all five structure, information and data collected during the NDT testing has been taking into account on various parameters in order to determine the effect of age and concrete cover over the condition of concrete structures. In the present research, the data obtained from field has been plotted to evaluate the effect of age and concrete cover and condition of structures against the NDT methods. UPV of concrete, rebound number of structures have been table and fitted in such a way that the obtained equations have been considered for describing relation between these parameters the result of all the structure are as follow.

- **RESULTS**

A. TEST RESULTS OF STRUCTURE NO. 1

Tests were conducted on some of the Columns of Structure No. 1 for the assessment of their quality. The observations, results have been tabulated below in table No 3.

STRUCTURE

1 COLUMN

Structure members.	Rebound number	UPV value (m/s)	Concrete Cover (mm)
COL-1.	44	4320	40
COL-2.	41	4150	40
COL-3.	42	4250	40
COL-4.	41	4115	40
COL-5.	40	4030	40

Table 3: Structure -1 Rebound, UPV value with concrete cover.

B. TEST RESULTS OF STRUCTURE NO. 2

Tests were conducted on some of the beam of Structure No.2 for the assessment of their quality. The observations, results tabulated below in table No 4.

ISSN No:-2456-2165

STRUCTURE -2
BEAM

Structure members.	Rebound number	UPV value (m/s)	Concrete Cover (mm)
BEAM-1.	41	4050	25
BEAM-2.	39	3850	25
BEAM-3.	40	4015	25
BEAM-4.	40	3950	25
BEAM-5.	41	4010	25

Table 4: structure-2 rebound, UPV value with concrete cover.

C. TEST RESULTS OF STRUCTURE NO. 3

Tests were conducted in the structure member of the Columns, No.3 for assessment of quality. The observations, results have been tabulated below in table No 5.

STRUCTURE -3
SLAB

Structure members.	Rebound number	UPV value (m/s)	Concrete Cover (mm)
SLAB-1.	38	3950	40
SLAB-2.	37	3820	40
SLAB-3.	40	4015	40
SLAB-4.	36	3620	40
SLAB-5.	34	3530	40

Table 5: structure-3 rebound, UPV value with concrete cover

D. TEST RSEULTS OF STRUCTURE NO. 4

Tests were conducted on the structure member of slab in Structure No.4 for assessment of quality. The observations, results have been tabulated below in table No 6.

STRUCTURE -4
COLUMN

Structure members.	Rebound number	UPV value (m/s)	Concrete Cover (mm)
COL-1.	35	3550	20
COL-2.	38	3800	20
COL-3.	39	4015	20
COL-4.	33	3410	20
COL-5.	32	3150	20

Table 6: structure-4 rebound, UPV value with concrete cover

E. TEST RESULTS OF STRUCTURE NO. 5

Tests were conducted all the structure member of the beam of Structure No.5 for assessment of quality. The observations, results have been tabulated below in table No 7.

STRUCTURE -5
BEAM

Structure members.	Rebound number	UPV value (m/s)	Concrete Cover (mm)
BEAM-1.	31	3150	25
BEAM-2.	30	2950	25
BEAM-3.	30	2850	25
BEAM-4.	31	3005	25
BEAM-5.	30	2750	25

Table 7: str-5 rebound, UPV value with concrete cover

ISSN No:-2456-2165

After taking physical analysis of all five structure, information and data collected during the NDT testing has been taking into account on various parameters in order to determine the effect of age and concrete cover over the condition of concrete structures. In the present research, the data obtained from field has been plotted to evaluate the effect of age and concrete cover and condition of structures against the NDT methods. Graphs between age and UPV of concrete, rebound number of structures have been plotted and fitted in such a way that the obtained equations have been considered for describing relation between these parameters.

F. EVALUATING THE CONDITION OF STRUCTURES BASED ON THE RESULTS

Major objective of the present work is to determine the condition of structure by testing concrete cover, UPV and rebound number as well as finding the age of the structure. Following table presents the conditions of structure based on UPV as per Indian practice code, for presents research we rated these conditions in five different categories from D-1 to D-4. Where, D-1 represents the very good condition of NDT test value and D-4 represents poorest condition of NDT test value are combined value of ultrasonic test and rebound hammer test represent in following table as with value of means of rating higher than 4.0 value as good quality and less than 3.0 values as poor quality in table 7.

Rebound hammer value	UPV value Km/sec	Concrete quality rating	Condition
>4.0	Above 4.5	Very good	D-1
3.5 to 4.0	4.0 To 4.5	Good	D-2
3.0 and 3.5	3.5 To 4.0	Fair but may be porous	D-3
2.5 and 3.0	3.0 To 3.5	poor	D-4
2.0 and 2.5	2.0 To 3.0	Very poor and low integrity, large voids suspected	D-4A

Table 8: Rating of concrete Structure as per IS- 13311-1 method of NDT testing

Following table presents the condition of surveyed structure based on above condition rating system.

- As per rating condition in the categories D-1 no evacuation needs minor repair only.
- As per rating condition in the categories D-2 no evacuation needs only minor structure repairs.
- As per rating condition in the categories D-3 to be evacuated but no demolition. Requiring some structural elements repair.
- As per rating condition in the categories D-4 to be evacuated and partial demolition requiring major structural repair.
- As per rating condition in the categories D-4A to be evacuated and demolition immediately.

Structure No.	Classification	Age (years)	Concrete Cover (mm)	Rating	Condition
1	Structure1	15	40	>4.0	D-1
2	Structure2	20	25	3.5 to 4.0	D-2
3	Structure3	30	40	>4.0	D-1
4	Structure4	40	20	3.0 and 3.5	D-3
5	Structure5	50	25	>3.0	D-4A

Table 9: Condition of surveyed structures as obtain result

Following figures present the change in condition of structures with increase in age of the structures.

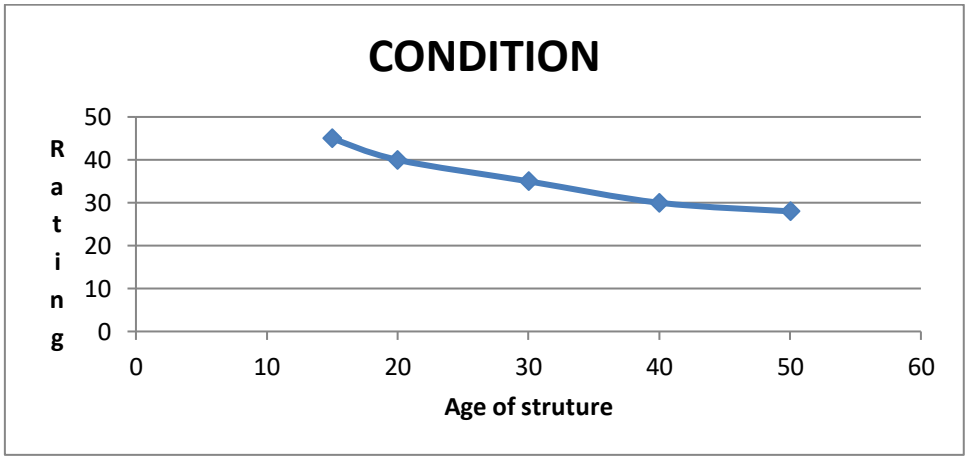

Fig. 2: condition of structure with age

ISSN No:-2456-2165

From the above figures it has been observed that condition of structure deteriorates with increase in age of the structures. Study of Effect of results data on the Rebound values and Ultra sonic pulse velocity on old building structure reflect condition and rating.

- **RESULTS**

After taking physical analysis of all five structure, information and data collected during the NDT testing has been taking into account on various parameters in order to determine the effect of age and concrete cover over the condition of concrete structures. In the present research, the data obtained from field has been plotted to evaluate the effect of age and concrete cover and condition of structures against the NDT methods. UPV of concrete, rebound number of structures have been table and fitted in such a way that the obtained equations have been considered for describing relation between these parameters the result of all the structure are as follows.

- As per result structure No -1 is in the categories D-1 no evacuation needs minor repair only.
- As per result structure No -2 is in the categories D-2 no evacuation needs minor structure repairs.
- As per result structure No -3 is in the categories D-1 no evacuation needs minor repair only.
- As per result structure No-4 is in the categories D-3 to be evacuated but no demolition requiring some structural elements repair.
- As per result structure No -5 is in the categories D-4A to be evacuated and demolition immediately.

G. BASED ON THE CONDITION OF STRUCTURES VARIOUS RETROFITTING METHODS FOR REPAIR AND REHABILITATION OF SURVEY STRUCTURE PROPOSED ARE.

The present work after results determine the condition of structure as per testing and Indian practice code, for present's research we rated these conditions in five different categories from D-1 to D-4. Where, D-1 represents the very good condition of NDT test value and D-4 represents poorest condition. So according categories of NDT test result value are Table 9.

STRUCTURE NO.	AGE (YEARS)	CONDITION	METHODS FOR REPAIR AND REHABILITATION
Structure1	15	D-1	Routing and sealing, Dry packing
Structure2	20	D-2	Carbon Wrapping, Strengthening of structure
Structure3	30	D-1	Column jacketing and Guniting
Structure4	40	D-3	Epoxy injection and Chemical Grouting
Structure5	50	D-4A	DEMOLITION

Table 10: PROPOSED METHODS FOR REPAIR.

V. CONCLUSIONS AND FUTURE SCOPE

- Evaluation condition old concrete building will help to proposed the service life of structure.
- Dilapidated of building structure with time is normal phenomenon .But rate of degradation depend upon maintenance condition of concrete structure.
- Deterioration of concrete structure also depends upon several parameters such as age, concrete cover, surrounding atmosphere or other influencing parameters.
- Three Non destructive testing methods were applied in this research work for monitoring condition of old concrete structures.
- Practically 5 old concrete building structure was tested in this study with around 25 structure elements in total, five from each structure.
- Structures of different occupancy and type were selected from different locations of Bhopal.
- Cover meter test has been used to determine the concrete cover of the structures. No significant effect of concrete cover was observed on the UPV and condition of structures.
- From regression analysis it has been observed that strength and condition of structures correlate with the NDT test value of UPV test and rebound hammer test results.
- Repair and Rehabilitation is necessary to save from uncertain failure of structures.
- It is recommended for old buildings which have some signs like cracks, corrosion of embedded materials, etc. Therefore, timely maintenance of structures is required.

REFERENCES

[1.] Kumar, mahesh, s. kaleem afrough zaidi, s. c. jain, and k. v.s.m. krishna. 2019. "reliability of non-destructive testing methods in the assessment of the strength of concrete columns reinforced with two layers of transverse confining stirrups: empirical evidence." international journal of recent technology and engineering 8 (2): 3450–59.

[2.] Ravi kumar, nandipati s.m., t. barkavi, and c. natarajan. 2018. "structural health monitoring: detection of concrete flaws using ultrasonic pulse velocity." journal of building pathology and rehabilitation 3 (1): 1–9.

[3.] Concu, giovanna, and nicoletta trulli. 2018. "concrete defects sizing by means of ultrasonic velocity maps." buildings 8 (12).

[4.] Adamatti, d. s., lorenzi, a., chies, j. a. & silva filho, l. c. p. analysis of reinforced concrete structures through the ultrasonic pulse velocity: technological parameters involved. rev. ibracon estruturas e mater, 358–385 (2017).

[5.] Hasbullah, mohd amran, rohana yusof, and mohd nazaruddin yusoff. 2017. "assessing the performance of concrete structure based on the width of the crack using upv." journal of engineering science and technology 12 (special issue): 17–25.

[6.] Syamilah yacob & Azlan shah ali. building condition Assessment lesson lear from pilot project comparative relationships. j. MATEC Web of Conferences 66, 00072 (2016).

ISSN No:-2456-2165

[7.] Breesem, khalid m., manal m. abood, and a. b.m.a. kaish. 2016. "estimating strength properties of self-compacting concrete incorporating cementitious materials based on ultrasonic waves." aip conference proceedings.
[8.] Owaid, haider m., roszilah b. hamid, and mohd r. taha. 2016. "variation of ultrasonic pulse velocity.
[9.] Gehlot, tarun, dr. s.s. sankhla, dr. s.s. gehlot, and akash gupta. 2016. "study of concrete quality assessment of structural elements using ultrasonic pulse velocity test." iosr journal of mechanical and civil engineering 13 (05): 15–22.
[10.] Turgut, p. research into the correlation between concrete strength and upv values. civil engineering vol. 12 1–7 (2014).
[11.] Sanjeev verma,S bhadauria and Saleem akhtar p. research into the The deterioration of concrete structures in the last few decades calls for effective methods for condition evaluation and maintenance. This resulted in development of several nondestructive testing (NDT) techniques for monitoring civil infrastructures. Hindawi Publishing Corporation Journal of Construction Engineering Volume 2013, Article ID 834572, 11(2013).
[12.] Ongpeng, jason maximino co. 2012. "ultrasonic pulse velocity test of reinforced concrete with induced corrosion." asean engineering journal 7 (2): 9–17.
[13.] Demirboğa, ramazan, ibrahim türkmen, and mehmet b. karakoç. 2012. "relationship between ultrasonic velocity and compressive strength for high-volume mineral-admixtured concrete." cement and concrete research 34 (12): 2329–36.
[14.] Adandoust, rahmat, and s. yasin mousavi. 2012. "fresh and hardened properties of self-compacting concrete containing metakaolin." construction and building materials 35: 752–60.
[15.] Rodríguez, n. husillos, s. martínez ramírez, m. t.blanco varela, m. guillem, j. puig, e. larrotcha, and j. flores. 2010. "re-use of drinking water treatment plant (dwtp) sludge: characterization and technological behaviour of cement mortars with atomized sludge additions." cement and concrete research 40 (5): 778–86.
[16.] Lai, w. l., y. h. wang, s. c. kou, and c. s. poon. 2012. "dispersion of ultrasonic guided surface wave by honeycomb in early-aged concrete." ndt and e international 57: 7–16.
[17.] Lorenzi, alexandre, luiz carlos, silva filho, luciani somensi lorenzi, roseane shimomukay, and josué argenta chies. 2011. "5th pan american conference for ndt monitoring concrete structures through upv results and image analysis," no. october.
[18.] Güneyisi, erhan, mehmet gesolu, and erdoan özbay. 2010. "strength and drying shrinkage properties of self-compacting concretes incorporating multi-system blended mineral admixtures." construction and building materials 24 (10): 1878–87.
[19.] Lorenzi, alexandre, francisco teston tisbierek, luiz carlos, and silva filho. 2007. "ultrasonic pulse velocity analysis in concrete specimens 2 . concrete evaluation considering nondestructive testing," no. october.
[20.] Arikan, metin, konstantin sobolev, tomris ertün, asim yeğinobali, and pelin turker. 2007. "properties of blended cements with thermally activated kaolin." construction and building materials.
[21.] Turgut, p. & kucuk, o. f. comparative relationships of direct, indirect, and semi-direct ultrasonic pulse velocity measurements in concrete. russ. j. nondestruct.745–751 (2006).
[22.] Philippidis, t. p., and d. g. aggelis. 2003. "an acousto-ultrasonic approach for the determination of water-to-cement ratio in concrete." cement and concrete research 33 (4): 525–38.
[23.] Costa Anumba and Appleton S.different types of concrete structures, subjected to harsh marine environment that deteriorated due to chloride-induced corrosion. Tests performed in depth inspection Requirements for the prioritization of predictive building maintenance. Journal of Facilities, 15(3/4), 97-104.(2002)
[24.] Abbott, G. R., Mc Duling, J. J., Dr, P. S., & Schoeman, J. C. Building Condition Assessment: A Performance evaluation tool towards sustainable asset management. CIB World Building Congress, 649- 662.(2007) 12. Kempton, J., Alani, A., & Chapman, K. (2001).
[25.] https://civildigital.com.