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An investigation of historical and contemporary buildings with regards to their masonry, materials, and structural integrity

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Abstract - *Old Structural Palaces are still standing on their own because of their construction technology and materials. Historical structures made in the Region of Rajasthan, withstood thousands of years despite the harsh climatic conditions, mainly due to their building materials and techniques of construction. Modern buildings structure and shopping malls are built to meet the needs of present time as they have become necessary in modern times. In modern structures the construction time have become significantly lower compared to historical structures. In Historical structure, "Sajjangarh" was chosen, which is the most popular and heritage building which is stated on Basundhra hills in Udaipur Rajasthan. It is the place of magic technologies with its structure. In modern structure," Celebration shopping mall" was chosen, which is most popular building located at Bhuwana Udaipur Rajasthan.*

This research shows the different technology adopted for both structure to explore the strength and weakness with the advantages and disadvantages. Also included the comparison of materials, i.e; lime, cement, natural gum etc and describe the negative and positive impact of environment. The comparison of the technology used for construction was done in this research. In this research shows both structure differences between the utilization of mechanical and manual techniques and this comparison outcome shows the stability according to time and eco-friendly manner in both structures. Tests on universal Testing Machine was done for in situ determination of the strength of materials used for both the structures.

Key Words: Historical Structure, Modern structure, Construction materials, Technology, Strength.

1. INTRODUCTION

During the era of king and people, safe and strong forts were built. Many grand temples and fort buildings came to the ground (Rajesh N, 2017). Many big empires were established in our country India and the buildings of that era still exist. These buildings which are our heritage are called historical structures. The present era is the era of modernity in which globalism has entered and we have learned the development of technology and we have been able to build buildings with modern facilities (Subramaniam S. R. 2016). If seen from the researcher's point of view, even today we have many questions in our mind, the present buildings are not very safe and durable, the modern buildings which are more than 50 years old start appearing in a dilapidated condition, whereas the structures of the buildings which are 400 years old are safe and strong. The technology and speed of construction has increased due to which construction work is being completed quickly in less time whereas the buildings and structures of 400 years ago used to take a lot of time and money (Rajesh N, 2017). What would have been the technology at that time, is there a basis for comparison between the present technology and the old technology, for this purpose the presented work has been done keeping this as the subject of the study (Subramaniam S. R. 2016). This study could help in understanding the material, construction method, technology, maintenance, safety and strength used in the construction of historical and modern buildings and structures and throw light on its cultural and historical importance.

Historical structure means forts, temples, buildings, palaces, buildings, bridges and tunnels which are more than 400 years old and which still exist today. Whether those structures are made of stone, they still stand firm with their existence. The repair work of these structures is done as per that time only (M. Hegazy, 2014). There is something special about such buildings whose art of construction and method of maintenance are important to know today. Modern structures include buildings, temples, buildings, bridges and tunnels built in the last 100 years. Which are also maintained and repaired using modern methods (Subramaniam S. R. 2016). Modern structures are based on new technology and new building materials. Incorporation of architectural science is also seen in modern structures. The less space has also been utilized well. But in this the thickness of the walls has been reduced and maximum space has been utilized. The modern building is in frame based structure.

If seen in the present context, there is a need for its study because the heritage is never lost for future and new development in our country India (Menon, 2014). Efforts are made to preserve historical structures so that the coming generations can know the pride of their country. Studies are needed to understand the preservation of these historic structures (Rajesh N, 2017). Besides, it is also necessary to study and cherish how modern structures are maintained and how modern structures are being constructed. Future researchers can carry forward their research through this. This paper deals with, the construction technology used for historical and modern structures, the materials used in the construction of historical and modern structures and the strength of historical and modern structures. According to the main objective of the research study, to understand the historical and modern structures of Udaipur, the method of their construction, to identify the construction materials used, to analyze and comparative study of the methods of maintenance. Certainly this research will contribute to understanding the difference between historical and modern construction methods.

2. LITERATURE REVIEW

In June 2017, N. Rajesh published his review on "Conservation of Heritage Structure of Danish Fort at Tranquebar Village, Tamilnadu," which outlines the structure's brief history, previous conservation efforts, and calls for more study to increase the structure's lifespan and transfer knowledge of lessons learned to conserve other types of structures. S. Raja Subramaniam published his study of "Repair and Rehabilitation of Heritage Buildings" in April 2016. This paper discusses the repair and rehabilitation play a significant part in the current state of building research since they are essential for building applications. In the review, titled "Conservation of Coral Stone Architectural Heritage on the Coast of East Africa," Maurizio Berti (November 2015) came to the conclusion that the foundation of the preservation process for coral stone structures is knowledge and mastery of their physical and chemical phenomena. According to 'The Importance of Heritage Conservation', (March 2015), heritage conservation is crucial for locating, cataloging, assessing, and safeguarding cultural and historical treasures. Heritage building preservation is a key strategy for urban growth, as evidenced by some global cities. It is crucial for defining the landmark within the protected region, as well as for the economy and the travel and tourism sector. According to Aran Menon (October 2014), "Heritage Conservation In India," and "Conservation of Heritage Structures," are interdisciplinary endeavours in which traditional knowledge of building materials, techniques, and specifications is introduced to the world of current conservation engineering practitioners with the aim of fusing it with contemporary tools and practices. Building India's capacity in structural safety-centric conservation engineering is a significant challenge. According to EncaMustafaraj's analysis in May 2014 titled "Repair and Strengthening of Historical Structures; Naziresha's Mosque in Elbasan," the mosque shows structural flaws. Deterioration of surface plaster, loss of masonry units, structural and non-structural fissures throughout the mosques, damaged roofing and drainage systems, sanding and suffusion phenomena, etc. are a few of the most prevalent issues. Some of the suggested actions to be made to protect the mosque for the future include: injecting filler into the voids; applying local reconstruction; using CFRP and longitudinal FRP bars; and others. M. Hegazy reviewed "Conservation of Historical Buildings" in March 2014. An integrated team of highly qualified professionals must be included in the process of re-qualifying historic buildings, among other key conservation process requirements that were specified. The following major professions play a significant role in the aforementioned process: architects, archaeologists, building economists, structural, mechanical, and electrical engineers, art historians, material scientists, craftspeople for each material, building contractors, surveyors, town planners, conservators, environmental, historical garden engineers, and curators. S.SaileyshSivarajaa, et al. (2013) reviewed the topic "Preservation of Historical Monumental Structures Using Fibre Reinforced Polymer" and came to the conclusion that FRP has various advantages over traditional materials when it comes to strengthening and retrofitting. Due to its thinness, its application does not add weight to already-existing structures. It supports the preservation of monumental structures' cultural heritage. It won't corrode. Experiments have shown that externally bonded FRP reinforcement is an effective way to improve the stiffness, strength, and energy absorption of poorly defined RC joints in shear. A relatively little amount of FRP area increased both the maximum lateral load capacity and the total energy lost by roughly 70 to 80 percent. In their assessment of "Conservation Plan for Historic Buildings from Building Control Administration Perspective," Brit AnakKayan, FaridWajdiAkashah, and NorHanizaIshak (2013) note that the promotion of conservation plans has increased interest in maintaining historic buildings. However, from the perspective of building control administration, conservation plans for historic structures face a wide range of significant problems. Heritage Conservation And Architectural Education, by Mohga E. Embaby (December 2013), proposes an educational methodology for dealing with heritage conservation projects: "adaptive reuse of historic buildings" in design studios of architecture and interior design programs, by promoting a design philosophy which supports the integrated approaches of revitalizing heritage values of the traditional communities and creates new activities appropriated with. Nonlinear Analysis Of Historic And Contemporary Vaulted Masonry Assemblages was reviewed by O.A. Kamal, G.A. Hamdy, and T.S. El-Salakawy in November 2013, and This study examines the nonlinear behavior of unreinforced masonry assemblages, particularly curved parts like arches, vaults, and domes, using both analytical and experimental methods. Neha Jain reviewed "Conservation Practices in India: A Case Study of Jaisalmer Fort" in December 2012. The purpose of this study is to determine the advantages and disadvantages of ASI and

INTACH through case study analyses of projects at the Jaisalmer fort. The purpose of the study is to determine how effective these organizations are at protecting monuments. As a result of the current situation, ASI must create a new amendment that gives considerably greater thought to the nation's current heritage and enforcement. The ASI must safeguard all of the nation's heritage assets, not just the monuments. A far longer list of cultural heritage should be included in the concept of protected monuments.

3 MATERIALS AND METHODOLOGY

Analytical and comparative studies on technology of historical and modern structures, has been carried out at the different locations in Udaipur. Which is located at a height of 582.17 m above sea level, it is located at latitude 24^{0}34'48” N and longitude 73^{0}40'48” E. It is positioned in the agro climatic zone IV-A (Sub-humid, southern plain and Aravalli hills of Rajasthan). These areas have a mixed climate, with temperatures ranging from 40°C in the summer to around 4°C in the winter. The experiments have been conducted from November 2021 to October 2023.

Table -1: Site specification for study location

Month of Visit	Study location	Latitude and longitude	Type	Construction description	Materials used
Oct 2022	Sajjan garh Fort	24.594°N 73.639°E	Historical Structure	Load Bearing Structure	Stone, marble, mud, surkhi, Mild Steel, lime and timber, river sand.
Jan 2022	Celebration Mall	24°36'44" N 73°42'8"E	Modern Structure	Framed Structure	R.C.C. Concrete Bricks, sand, steel, marble, cement.

1. Sajjan garh fort (historical structure) Technology used for construction

During the study of the historical structure, Images and views were taken as per the study points and after in-depth study, they were further analysed.

Fig. 1: Stone railing balcony

Fig. 2: Main door of sajjan garh fort

Fig. 4: Staircases

Fig. 5: Artistic windows and domes

Technology used for construction

- This structure was mainly built during 1884 manually without machines. It is situated in Basundara hill of Aravali Mountain range. The hill consists of mostly high-grade metamorphism of sedimentary or igneous rocks (https://en.wikipedia.org/wiki/Aravalli_Range, Assessed on 17.10.2023). With the help of Crow bar, Icelandic, spade, shovel hammer and chisel the base of the foundation of the fort was done.
- At that time laborers, elephant carts and bullock carts were used to lift up construction materials.
- The foundation of fort was made of marble pillar, deep foundation were used.

(traveltourguru.inAssessed on 17.10.2023)

- Fully Paneled Double leafed doors of Timber were installed.
- Fully Paneled and glazed window of Timber were installed.
- Stone carved skylights were installed for ventilation.
- Flag stone flooring were laid in outer area of the fort.
- Oriental designed masonry domes were built in fort.
- Mainly dark brown and grey igneous stones and white marble were used to build this structure.
- Stone masonry was used for partition; Coursed random rubble and Ashalar masonry were used in construction.
- Architecture and Vaastu Shastra were used in the orientation of this fort.
- To carry out construction work at height, bamboo, poles, ropes etc. were used.
- Lime mortar were used for masonry and plastering work.
- Rain water was used in construction work.
- There was no use of chemical admixture.

2. Celebration mall (modern structure)
Technology used for construction

During the study of the Modern structure, Images and views were taken as per the study points and after in-depth study, they were further analysed.

Technology used for construction

- This structure has been built during 2007 to 2010. It is located in Bhuwana, on the border of Udaipur on NH 8. It is constructed with the help of new mechanical machines and high-tech equipments. Before construction of mall the particular area was agriculture land.
- In this structure laborers use bulldozer, crane and excavator etc. has been use to lift up construction materials.
- The foundation of mall has been spread footing and raft footing, Shallow foundation has been use.
- Brick masonry, aluminum section, fiber sheet and glass, wood, timber has been used for partition.
- English and Flemish bond of bricks has been use in masonry.
- Terrazzo floor lay in square blocks in flooring.
- Glass sliding doors are installed in mall.
- Glazed window are installed in mall.
- Exhaust fan are used for ventilation.
- Steel members fabricated domes imposed in mall.
- Mainly Nimbhara stones, white marble& Jaisalmeri stone and bricks has been use to build in this structure.
- Architecture and engineering design has been use in the construction of mall.
- To carry out construction work at height steel scaffolding and cranes has been use.
- Cement mortar has been use for masonry and plastering work.
- Admixture and chemical has been use in reinforcement concrete cement.
- Under ground water has been use for all type of construction work like foundation, masonry, plastering and curing.

Comparison of historical structure Sajjangarh fort with modern structures Celebration Mall:

- The plinth of the fort is more than 2 meters above the foundation. That is, in old buildings, to raise the building from the ground level, the plinth level of the building was kept higher than the foundation to strengthen the foundation.
- The walls of the fort were made more than 1 meter thick.
- The foundation of the fort was laid on marble pillars.
- Lime plaster was done on the walls.
- In this, the height of the rise of stairs more than 1 feet.
- Jharokas, domes and arches were made in it.
- Its geometry was amazing.
- Special attention was paid to the arrival of the sun's rays.
- Full path for sunlight was kept.
- Provision for skylight was kept.
- In this, height was given importance.
- Open spaces and courtyards were created in it.
- The fort is naturally warm in winter and cool in summer.
- Its roof is made of stone slab on steel girders.
- Inside the building the stairs were not made wide enough for entry.

Comparison of Celebration Mall with historical structures Sajjangarh Fort:

- The chair level of the mall is 3 feet from the foundation. Therefore, at present the foundation is being kept less height.
- The walls of the mall were made 6 to 9 inches thick.
- Cement plaster was done on the walls.
- In this, the height of the rise of stairs is 6 to 7 inches.
- Windows and vents are made to show, in which there is no provision for the flow of air.
- It has glass/jharokha closed windows.
- More attention was paid to its utility than its geometry.
- The arrival of sun rays is negligible.
- There is no provision for sunlight to enter.
- Provision for skylight was not made, instead a dome made of fiber sheet and iron was made in the middle.
- In this the height of the roofs was kept very low.
- There is less open space in it. The width of the corridor is less.
- It naturally does not remain hot in winter and cold in summer. Air conditioning was used for this.
- Its roof is made of RCC.
- The width of staircase is enough to move.

Table 2 – Construction Materials used in Sajjangarh Fort

S.No.	Materials	Description
1	Marble	Used for flooring, wall cladding &Jharokha's
	Basalt Stone	Used in outer flooring
	Unfinished Marble Stone	Wall masonry
2	MS Steel	Steel Girder's has been Used in slab
3	Lime	Lime is used for plastering purpose and as a mortar masonry structure
4	River Sand	Used in mortar
5	Timber	Used in doors and windows
6	Jaggary	Used for Boundary Wall
7	Glass	Used For Door, Window and ventilation
8	Copper	Used for Domes
9	Mud	Used for Boundary stone masonry
10	Surkhi	Used for Mortar
11	Rain Water	User For Construction Work

Table 3– Construction Materials used in Celebration Mall

S. No.	Materials	Description
1	Marble	Used for flooring, wall cladding & Jharokha's
	Basalt Stone	Used in outer flooring
	Unfinished Marble Stone	Wall masonry
2	MS Steel	Steel Girder's has been Used in Doms
3	Reinforcement Steel	Used for Beam, Column, Slab, Foundation
4	Cement	Used for Mortar, Plaster and Masonry
5	Concrete	Used for RCC, PCC, Lintel, Column and Beam
6	Timber	Used in doors and windows
7	Glass	Used for Doors, Windows, Railing
8	Fiber	Used for Doms
9	Tiles	Used for Flooring
10	Brass	Used for Doors, Windows and Floor designed
11	Bricks	Used for Wall Partition
12	Colour and Paints	Used for Finishing
13	River Sand	Used for Mortar
14	PVC	Used for Light and Sanitary Feeting
15	Aluminium	Used for Section Partition

2 Strength analysis of historical and modern structures.

To achieve this objective below mentioned steps were taken. To study the strength of the historical structure compressive strength test, tensile strength test. To study the compressive strength of historical structure basalt and unfinished marble stone was chosen, as the main compressive member of Sajjan Garh fort are these stones. For the modern building compressive strength of concrete, brick was done, as in modern structure these were the main compressive member. In historical structure mild steel was used in the form of steel girder as tensile member. For modern structure R.C.C bar of strength Fe 415 and Fe 500 were used as these were used in the Celebration mall.

2.1 Historical Structure: Sajjangarh Fort

The materials used in Sjjangarh Fort was described in section 3.2. The tests which were used to determine the strength of the structure is described below.

Compressive strength test of Stone: The average compressive strength of the stone when the load is parallel to and perpendicular to the bands is 104.9 MPa and 86.1 MPa, respectively. The strength of masonry increases with an increase in mortar strength. Stone masonry strength is again higher when loaded parallel to the mineral bands. A building stone's compressive strength should be 60 to 200N/mm2. Location and composition determine a stone's durability. The size, structure, and type of minerals in a stone make up its composition. The ASTM tests for durability and has established guidelines for Limestone and sandstone. Below table no. 3.3.1shows the properties of stones from various stones used for construction materials. For Sajjangarh fort mainly Marble and Basalt stone was used this is show in Fig No.3.7 and 3.8, Fig3.9 and 3.10.

Table 4: Properties of Stones

Types of Stone	Weight (kg/m3)	Compressive Strength (MPa)	Water Absorption (Percent by weight)
GRANITE	2643 – 3204	139 – 309	0.002 - 0.2
SANDSTONE	2242 – 2643	31 – 108	1.5 – 6
LIMESTONE	2000 – 2880	19 - 193	0.25 – 7.5
MARBLE	2963 – 3043	93 – 162	0.001 – 0.06
SLATE	2800 – 2880	124 – 185	0.15 – 0.25

Procedure of Crushing Test or Compression strength test on stone:

The sample taken for the test should be a cube of size 40mm×40mm×40mm or 50mm×50mm×50mm. The sides of the cubes are made smooth by dressing and polishing. The test should be carried out on dry as well as on saturated samples.

For dry samples, cubes are placed in an oven at 105°C for one day and then cooled in a desiccator to room temperature. For saturated samples, specimens should be placed in water for about 72 hours and tested in a saturated condition.

Each Specimen is tested individually in the **universal testing machine.**

1. Tensile Strength MS Mild Steel Girder

Tensile strength of steel is predefined in IS 800:2007. The steel girder used in Sajjangarh fort as a tensile material is of ISHB 400. (Taken as per sample appearance from the site.) The tensile strength of that size the girder given in IS 800:2007.

Mild steel is better used for low-stress applications due to its ease of fabrication and low cost, while carbon steel (from medium carbon steel to ultrahigh carbon steel) is better used for high-strength applications due to its high carbon content and strength.

Mild carbon steel has a tensile strength of 370-500 MPa (53-73 ksi). This means that it can withstand a force of up to 370-500 Mega Pascal's (53-73 kilo pounds per square inch) before breaking or deforming

2.2 Modern Structure: Celebration Mall

The materials used in Celebration Mall were described in section 3.2. The tests which were used to determine the strength of the structure is described below.

2.2.1 Concrete Compressive Strength

Concrete compressive strength can vary from 2500 psi (17 MPa) for residential concrete to 4000 psi (28 MPa) and higher in commercial structures (IS 456:2000). According to IS 516: 2013Methods of Tests for Strength of Concrete (Eighteenth revision) the compressive strength test was done.

1. Procedure

1. The cement samples, on arrival at the laboratory, shall be thoroughly mixed dry either by hand or in a suitable mixer in such a manner as to ensure the greatest possible blending and uniformity in the material. The proportions of the materials, including water, in concrete mixes used for determining the suitability of the materials available, shall be similar in all respects to those to be employed in the work.
2. The quantities of cement, each size of aggregate, and water for each batch shall be determined by weight, to an accuracy of 0.1 percent of the total weight of the batch.
3. size as to leave about 10 percent excess after moulding the desired number of test specimens.
4. Test specimens cubical in shape shall be 15 × 15 × 15 cm. If the largest nominal size of the aggregate does not exceed 2 cm, 10 cm cubes may be used as an alternative. Cylindrical test specimens shall have a length equal to twice the diameter. They shall be 15 cm in diameter and 30 cm long. Smaller test specimens shall have a ratio of diameter of specimen to maximum size of aggregate of not less than 3 to 1, except that the diameter of the specimen shall be not less than 7·5 cm for mixtures containing aggregate more than 5 percent of which is retained on IS Sieve 480.

5. The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained.
6. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted.

6. Calculation

The measured compressive strength of the cubes shall be calculated by dividing the maximum load applied to the cubes during the test by the cross-sectional area, calculated from the mean dimensions of the section and shall be expressed to the nearest 0.5 N/mm^2.

1.2.2 Tensile strength of Reinforcements Steel:

Tensile test was conducted in Universal testing machine (UTM). The procedure is described below:
Procedure: Select the proper job and complete upper and lower check adjustment. Apply some Greece to the tapered surface of specimen or groove. Then operate the upper cross head grip operation handle & grip the upper end of test specimen fully in to the groove. Keep the lower left valve in fully close position. Open the right valve & close it after lower table is slightly lifted. Adjust the lower points to zero with the help of adjusting knob. This is necessary to remove the dead weight of the lower table. Then lock the jobs in this position by operating job working handle. Then open the left control valve. The printer on dial gauge at which the specimen breaks slightly return back & corresponding load is known as breaking load & maximum load is known as the ultimate load. Machines and tensile grips for tensile testing of steel reinforcing bars must be capable of applying very high loads. Based on ASTM specifications for various grades of rebar, the ultimate tensile strength to break rebar can range from 50 KN (11 kip) to 600 kN (135,000 lbf) for one size of rebar.

4 RESULTS

Both historical structures and modern structures reflect the technology of their respective times and the materials used. There are similarities as well as differences in both.

4.1 To study the construction technology and materials used of historical and modern structures.

Fig: 6 Steel Girder used in the Sajjangarh Fort

Fig. 7. Staircase used in sajjangarh fort

Fig. 8. Ramp used in sajjangarh fort entry

1. Duration of time in historical structures too long as well as compare to modern structures and the use of machinery in modern structures as compare to man power/labour.
2. Historical structure was based on load bearing structure and modern structures are based on framed structure.
3. According to research result that the historical structure are mostly situated on high rise plinth level and Wide area ,modern structure are situated in less plinth level and undersized area.
4. Staircase and ramp used in historical structure, lift and escalator in modern structure.

5. Historical structures have provision for natural light and ventilation and modern structures provide artificial resources like AC, heater, halogen.
6. Fig: 4.1 taken during the site investigation on 22.02.23, it is visible that ISHB 400grade of Steel Girder has been used. The Further strength analysis of the historical structure is done on this hypothesis.

4.2 To study the materials used in the construction of historical and modern structures.

Fig.11 lime plaster on wall surface

1. In historical structures lime used as a binding material in construction and cement use in modern structures.
2. In respect of Temperature Influence According to people survey the lime stone masonry structure are cold in summer and hot in winter or cement masonry structure cold in winter and hot in summer.
3. Historical structure was based on stone masonry and modern structures are based on bricks and concrete.
4. According to research result that the common thing in both structure are that the used material are some cheap and some costly.

4.3 Strength analysis of historical and modern structures.

To determine the compressive strength of concrete, rock and tensile strength of steel bar, laboratory tests were conducted as per IS 456:2000. The steel Girders used in the historical structure were ISHB400 (taken as per sample appearance from the site). Strength of the Steel Girder are calculated as per IS 800:2007 for this study, and to compare both the tensile strength of modern and historical structures. Design steps of steel tables are adopted for the design procedure of steel girder in the historical structures.

Design Procedure of Steel Beams

A beam section is usually chosen which can resists maximum bending moment occurring over its span. The shear stress and deflection for the chosen beam section are checked from given below design steps.

(i) Design for bending The bending stress σ_{bc} compressive or tensile at any point on a cross-section of a beam due to bending moment M is given by Eq.

$$\frac{M}{I} X\, y = \sigma_{bc}$$

Where
M = bending moment
I =moment of inertia of the cross-section of the beam
σ_{bc} = Bending stress (compressive or tensile) calculated at a point at a distance y from the neutral axis
The point of maximum bending stress occurs at the extreme fibre and the corresponding $\frac{I}{y}$ ratio is called the sectional modulus designated by **Z.**

(ii) Check for shear The shear stress τ at any point on the cross-section of a beam is given by Eq.

$$\tau = \frac{V}{I\, X\, b} X\, A\, X\, \bar{y}$$

Where
V = shear force at the section
I = moment of inertia of the section
b = width of the section at the point where shear stress is calculated
$A\ X\ \bar{y}$ = moment of the area abovethe level where the shearstres is calculated, about neutral axis of the section

(iii) Check for deflection The maximum deflection of a beam should not exceed $\frac{1}{332}$ of the span in general. This limit may be exceeded in cases where greater deflection does not affect the strength of crack the floor finishing. The maximum deflection in beams is given in general by Eq.

$$\delta = K\, X \frac{W\, X\, l^3}{E\, X\, I_x}\ cm$$

where δ= maximum deflecito n

K= a constant given in Table4.1
W= load on beam as shown in Table4.1
L= effective span
E= Young's modulus of elasticity= $2X10^4$kN/cm^2
I_x= moment of inertia of the cross section of the beam

(iv) Check for web crippling and web buckling

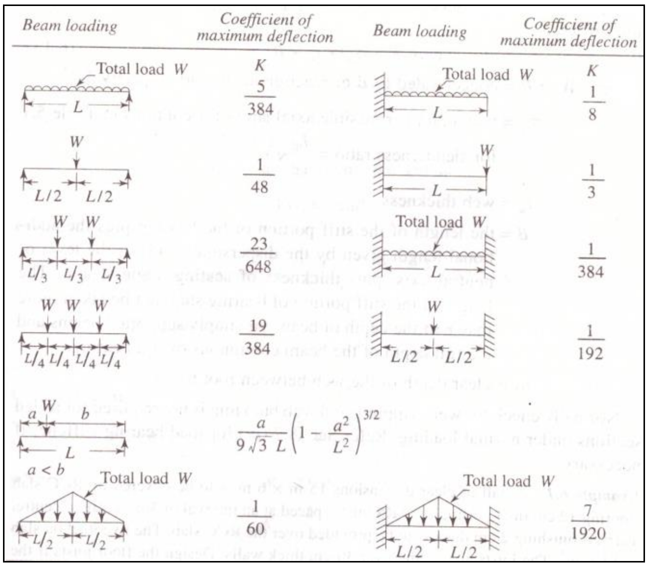
A beam may fail under a concen trated load or at end reaction due to crippling of web or by buckling of web Web crippling The dispersion of load is assumed to be at 30^0as shown in Fig.no4.8 The bearing stress in the web at the root of the fillet will be equal to

$$\frac{W}{t_w(a+2h_2\sqrt{3}} >\neq \sigma_p \text{ for intermediate loads}$$

$$\frac{R}{t_w(a+h_2\sqrt{3}} >\neq \sigma_p \text{ for end supports}$$

Where
W= concentrated load on the beam (N)
R= reaction at supports (N)
t_w= thickness of web (mm)
a = bearing length (mm)

Table No. 4.1 Show the coefficient of maximum deflection on various types of load on beam.



The average compressive strength of marble and basalt is found to be 105.58(N/mm²) and 165.70(N/mm²) respectively shows in Table no.4.2. In the comparison with the evacuated data, Malik et. al, 2017 also reported compressive strength of basalt stone 170 N/mm².

Compressive strength of Marble and Basalt Rock:

The Compressive strength of Marble and Basalt Rock tested by Universal Testing machine is given in the below Table No. 4.2.

Table 4.2: Test Result of Marble and Basalt Stone

SR. No.	Rock Type	Specimen size of rock(Taken as per IS-1121 Part-I 2013)cube(mm³)	Compressive strength (N/mm²)
1	Marble (Specimen no. 1)	100X100X100	102.70
2	Marble(Specimen no. 2)	100X100X100	115.65
3	Marble(Specimen no. 3)	100X100X100	98.40
		Average compressive strength of Marble: 105.58(N/mm²)	
4	Basalt (Specimen no. 1)	100X100X100	165.66
5	Basalt (Specimen no. 2)	100X100X100	170.65
6	Basalt (Specimen no. 3)	100X100X100	160.80
		Average compressive strength of Basalt: 165.70(N/mm²)	

Table no.4.3 and 4.4 shows the grades and compressive strength of concrete. Table no.4.5 and 4.6 shows the experimental value of compressive strength of concrete.

M25 grade of concrete is used in the slab construction in the celebration mall and **M30** is used in columns and beams.

Table No. 4.5: Recordings during Compressive Test on Concrete cube of grade M25 (1:1:2)

Sr. No.	Age of Cube	Size of concrete cube(mm³)	Weight of cubes in Kg	Failure Load in KN	Compressive Strength (N/mm²)	Avg. Compressive Strength (N/mm²)
1	7 days	150x150x150	8.480	380.5	16.91	16.88
2		150x150x150	8.500	358.8	15.94	
3		150x150x150	8.520	400.6	17.80	
4	28 da	150x150x150	8.510	643.4	28.50	27.90

5	ys	150x150 x150	8.500	584.2	25.90	
6		150x150 x150	8.470	661.4	29.30	

Table No. 4.6: Recordings during Compressive Test on Concrete cube of grade M30 (Design Mix)

Sr. No.	Age of Cube	Size of concrete cube(mm³)	Weight of cubes in Kg	Failure Load in KN	Compressive Strength (N/mm²)	Avg. Compressive Strength (N/mm²)
1	7 days	150x150 x150	8.600	437.1	19.42	20.22
2		150x150 x150	8.550	451.8	20.08	
3		150x150 x150	8.520	476.1	21.16	
4	28 days	150x150 x150	8.540	724.60	32.20	32.64
5		150x150 x150	8.610	735.5	32.68	
6		150x150 x150	8.570	743.9	33.06	

Fig. 13 Moulding of Concrete cube specimen

Fig. 15 Curing of Concrete cube

Fig. 16 Weighting of Concrete cube

Tensile strength test of steel: The Tensile strength test of steel tested by Universal Testing machine is given in the below table no. 4.7

Table No. 4.7: Test Result of Steel Bars

Sr. No.	Dia of Bar Fe 550 D (IS1786:2008)	length of bar, m	Weight per m	0.2% of proof stress on yield stress (N/mm²)	Elongation, %	Tensile Strength (N/mm²)
1	8 mm	1.0001	0.3878	623.3	27.5	715.1
2	10 mm	0.9900	0.6018	637.8	18.0	726.6
3	12 mm	0.9950	0.8640	674.8	20.0	727.4

4	16 mm	0.99 77	1.52 13	629.2	25.0	730.5
5	20 mm	0.99 60	2.48 50	707.5	17.0	787.4
6	25 mm	1.00 30	3.83 80	571.1	20.5	674.1

5 CONCLUSION

In this study the site selection was done at first. Celebration mall as modern structures and Sjjangarh fort as historical structures were chosen. Site visit was done. Then identification of material and construction technology was done. For strength analysis compressive and tensile strength was measured in Universal Testing Machine. For the strength of steel girders IS800:2007 code was followed.

1. According to research and site visit, data reports and identification it was noted that, in construction of historical structure Sajjangarh fort and modern structure celebration mall main materials used were stone, steel, concrete, steel girder.

2. The walls of all historical buildings were kept thick and plinth level was kept high. They were constructed by taking full advantage of natural environment air, water and light. Both reflect the importance of their times.

3. It was found that the historical structure is load bearing structure and the modern structure is mainly based on frame structure.

4. To get strength value of materials by performing Compressive strength and tensile strength laboratory test.

5. For rock sample basalt stone the compressive strength was found to be 165.70N/mm^2 and Marble stone the compressive strength was found to be 105.58N/mm^2.

6. For M25 grade of concrete the compressive strength of 28days was found to be 27.90N/mm^2 and for M30 grade of concrete the compressive strength of 28days was found to be 32.64N/mm^2.

7. The tensile strength from 8mm to 20mm steel bar was found to be in the range of 715.10 N/mm^2 to787.40 N/mm^2.

8. The tensile strength of 25mm steel bar was found to be 674.1 N/mm^2.

9. For steel girders ISLB, ISWB, ISMB, and ISHB, the design load was calculated according to IS800:2007code and steel table for apply load and span.

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