Revitalizing Structures: A Comprehensive Guide to Steel Section Rehabilitation

[1]Surabhi Jain, [2]Rashmi Sahu, [3]Dr. A.K. Dubey

[1]Research Scholar, M.Tech. (Structural Engineering)
[2]Research Scholar, M.Tech. (Structural Engineering)
[3]Professor & Principal, Dept. Of Civil Engineering,
Jhada Sirha Government Engineering College, Jagdalpur, C.G.

---***---

Abstract -*Since the late 20th century, the debate over renovating existing dwellings versus demolishing and constructing anew has intensified, driven by the need to revitalize urban centres. Despite its benefits, rehabilitation is not always the most cost-effective choice, and sometimes, demolition followed by new construction proves more advantageous. In the specialized field of repairs and rehabilitation engineering, expertise goes beyond conventional construction skills, requiring a delicate balance of advanced technology, trends, management, feasibility, and economy. Innovative methods aim to enhance the stiffness of steel members without increasing their weight, with the steel frame construction technique utilizing a grid of vertical columns and horizontal I-beams to support a building's floors, roof, and walls.*

Key Words: Rehabilitation, STAAD pro, Utilization ratio

1. INTRODUCTION

Repair and Rehabilitation in Civil Engineering is a skillful practice aimed at extending the service life of structures. It involves restoring a structure to its original state when facing defects, deterioration, or destruction. The ultimate goal is to maximize the functional utility of the structure, even allowing for modifications to meet new requirements. Structures may undergo Repair and Rehabilitation for reasons such as environmental deterioration, changes in functional or loading requirements, or damage from accidents. The process employs systematic approaches aligned with various strategies to achieve a desired level of structural longevity. The lifespan of a structure isgenerally influenced by factors like location, building material, technology, and workmanship.

1.1REHABILITATION VS DEMOLITION

Demolition means tearing down a structure, while rehabilitation involves preserving and renovating it. The choice depends on factors like cost, environmental impact, and historical significance. Rehabilitating a building, based on its historical or architectural value, cost efficiency, and environmental sustainability, can be faster and integrate with the community. Adaptive reuse, regulatory incentives, reduced construction risks, and aesthetic value also favour rehabilitation. The decision considers specific project needs, with site conditions like cost-efficiency, sustainability, quicker completion, community integration, adaptive reuse, reduced construction risks, and aesthetic appeal influencing the choice.

1.2REHABILITATION

Building rehabilitation involves repairing or modifying a structure to restore its usefulness, extending its service life. Advantages of rehabilitation include environmental sustainability by reducing CO_2 emissions compared to complete demolition and reconstruction. It also lowers costs, minimizes the need for new materials, enhances productivity, safety, and health, attracting investor interest. Rehabilitation can result in a higher-quality product and breathe new life into historic city centres by offering modern apartments in reconstructed buildings. In the construction sector, rehabilitation is expected to become increasingly relevant for people, the economy, and the planet's sustainability.

The rehabilitation of a building involves restoring or renovating it to meet current safety, functional, and aesthetic standards while preserving its historical or architectural significance. This typically includes structural repairs, upgrades to mechanical and electrical systems, accessibility improvements, and cosmetic enhancements. The goal is to extend the lifespan of the building, enhance its usability, and maintain its value for future generations.

1.3STIFFENER

Stiffeners, crucial in engineering and construction, reinforce structures and prevent deformation. Used in various industries, they add rigidity and prevent buckling or flexing. Available in different forms and materials based on the application, stiffeners ensure structures withstand loads without excessive deflection or deformation. Their design, tailored to project requirements, enhances overall stability and integrity.

1.4CHANNEL SECTION AS A STIFFNER

In order to improve stability and load capacity during retrofitting, channel sections are frequently utilized to reinforce structures. Installed at right angles to important structural components, such as beams or columns, they are placed carefully to reinforce weak spots. Because of their high strength-to-weight ratio, they have the advantage of being able to increase stiffness and strength without adding a lot of weight. These sections are readily and securely joined to the main structural members after being precisely produced to meet the specifications of the project. Because of their design flexibility, engineers can best arrange them depending on the properties of the structure. All things considered, retrofitting with channel sections is more affordable and enhances structural performance, guaranteeing safety and resistance to loads and changes in the environment.

1.5 STAADPRO

STAAD. Pro, developed by Bentley Systems, is a widely used structural analysis and design software for civil and structural engineers. Originally standing for "STA tic A nalysis and Design," it is employed in various industries, including civil engineering, construction, and infrastructure development. STAAD. Pro offers tools for structural analysis, design, and documentation, catering to complex structures with a focus on precision and safety. The software can generate wind and earthquake loads, design steel and concrete structures in compliance with country codes and perform both linear and nonlinear dynamic analysis. It features a user-friendly interface for quick learning.

1.6 UTILISATION RATIO

The usage ratio in STAAD.Pro is a measure of a structural member's suitability or efficiency in supporting applied loads. It is the ratio of the member's actual load to its capacity or maximum permitted load, and is usually stated as a percentage. A utilization ratio over 100% implies that the member is being overworked and may be in danger of failing, whereas a ratio below 100% shows that the member is not being fully utilized and has more capacity to carry more weight. Utilization ratios are a tool used by engineers to evaluate the safety and performance of structural parts, spot possible problems with the design, and make the required corrections to guarantee that every component performs to its intended capacity.

2. OBJECTIVE

1. The project aims to enhance the functionality, safety, and aesthetics of an existing structure through restoration, renovation, or adaptation.

2. When a building is structurally unsound or poses safety risks, the primary goal is to reinforce the structure, repair damage, and ensure compliance with current safety standards.

3. Retrofitting a building for improved energy efficiency and environmental sustainability is a common project objective.

4. The goal is to maximize project value within the budget, avoiding unnecessary expenses.

5.Commercial properties may undergo rehabilitation projects to increase asset value, enhancing marketability and potential return on investment.

6. Opting for a rehabilitation project over new construction is preferable for factors such as timesaving, cost efficiency, and overall economy.

3. LITERATURE REVIEW

3.1BUILDING REHABILITATION LIFE CYCLE ASSESSMENT METHODOLOGY–STATE OF THE ART by Charles Thibodeaua,b , Alain Bataillea,⁎ , Marion Siéc,d

In the quest for more sustainable construction practices, life cycle assessment (LCA) is acknowledged as a crucial method for exploring the potential environmental effects of materials, products, systems, or entire buildings. When applied to buildings, LCA typically aims to quantify the potential environmental impacts associated with various stages of a building's life cycle, including raw material supply, product manufacturing, construction-installation, building use, and end-of-life considerations. Recent reviews reveal that, since the late 1990s, 42 LCA studies have been conducted assessing both residential and commercial buildings. These studies utilize at least two midpoint indicators and consider manufacturing and building operation stages, although the focus is predominantly on new buildings.

3.2AN ENVIRONMENTAL AND ECONOMIC SUSTAINABILITY ASSESSMENT METHOD FOR THE RETROFITTING OF RESIDENTIAL BUILDINGS by Ikbal Cetiner , Ecem Edis

Due to the profound impact of a building's entire life cycle processes on both the environment and the economy, there is a growing interest in evaluating the sustainability of both new and existing constructions. In Turkey, a significant portion of the building stock predates the implementation of legislative measures addressing energy efficiency. This article presents a method for assessing environmental and economic sustainability, specifically focusing on the effectiveness of retrofits in existing residential buildings. The primary aim is to reduce space heating energy consumption and associated emissions. The proposed method, based on the life cycle assessment approach, evaluates the environmental and economic sustainability performance of retrofits, concentrating on the building envelope. This includes actions such as incorporating thermal insulation and replacing windows. The goal is to assist building owners, users, or architects in decision-making by identifying the most advantageous retrofit alternatives in the Turkish context. Currently, the database established using this methodology is tailored to detached buildings in Istanbul equipped with a natural gas-fired central heating system.

3.3USING STADD PRO: BUILDING DESIGN AND ANALYSIS by J. Mohan1 C. Selin Ravikumar2 and T.S. Thandavamoorthy3 (2017): -

The planning of contemporary civil engineering structures is highly intricate, with fundamental design playing a crucial role in various aspects. This design process entails manual load calculations and a comprehensive analysis of the entire structure using STAAD Pro. The structure is exposed to self-weight, dead load, live load, and wind load as stipulated under various load cases outlined in the paper. The authors also verified the deflection of different members under the specified loading combinations. The design of the building is based on the minimum requirements specified in Indian customary codes. These requirements, essential for the structural safety of buildings, are established by determining minimum design loads for dead loads, imposed loads, and other external loads that the structure must withstand. Strict adherence to loading standards recommended by the IS codes was maintained.

3.4BUILDING REHABILITATION VERSUS DEMOLITION AND NEW CONSTRUCTION: ECONOMIC AND ENVIRONMENTAL ASSESSMENT by Mª. Desirée Alba-Rodrígueza,⁎ , Alejandro Martínez-Rocamorab , Patricia González-Vallejoa , Antonio Ferreira-Sáncheza , Madelyn Marreroa

Regarding the topic investigated in this study, our findings suggest that the primary factors influencing the decision-making process between renovation, demolition, and new construction are threefold: investment costs, the condition of the building, and regulatory compliance. Other considerations, such as environmental, economic, and social principles, were regarded as having a less significant impact. Our evaluation of the environmental aspects of a building's life cycle led to the conclusion that, in a scenario where a building has a lifespan of 100 years, the total energy consumption over the building's lifetime is higher if the structure is either maintained in its original state or completely demolished and reconstructed. In contrast, ‘refurbishing the building results in lower energy consumption. Although reconstruction has a notable environmental impact, it also provides an opportunity to enhance the energy efficiency of the structure.

4.METHODOLOGY

Eight blocks with two storey make up a module that is used to analyze the structure. Different channels sections are used to stiffen the walls and the structure as a whole. Additionally, the combination with the best utilisation ratio is taken into account.

Utilization ratios of various channel section combinations are compared, and the results are displayed in a table.

Now, STAAD Pro software is used to compare the utilization ratio.Here are the actions to take:

Step 1-Modelling of structure

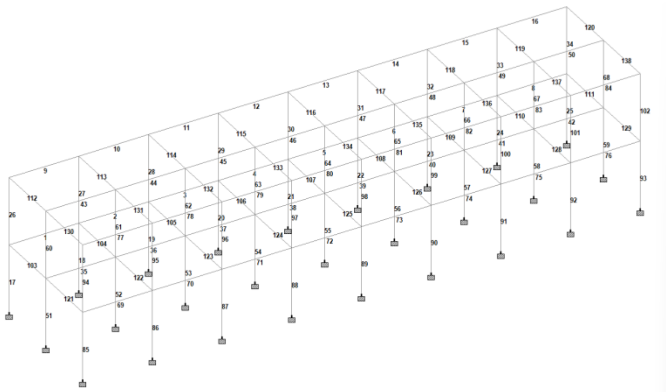

Fig. 1 – model

Step 2- Load calculation

Loads applied to the structure is taken as live load, existing slab load and new slab load. Calculation of load can be done as follows: -

Existing slab Dead load:

Thickness of slab = 200mm

Unit weight of RCC = 25KN/m^3

Floor load due to slab = 25*0.2

= 5KN/m^2

New slab Dead load:

Thickness of new slab = 200mm

Unit weight of RCC = 25KN/m^3

Floor load due to slab = 25*0.2

= 5KN/m^2

Cover in slab

At bottom = 1 inch = 25.4mm

At top = 1 inch = 25.4mm

Dead Load = 25*0.254*2

= 1.27KN/m²

Total dead load = 5+5+1.27

= 11.27KN/m²

Live load = 3KN/m²

Floor finish = 1 KN/m²

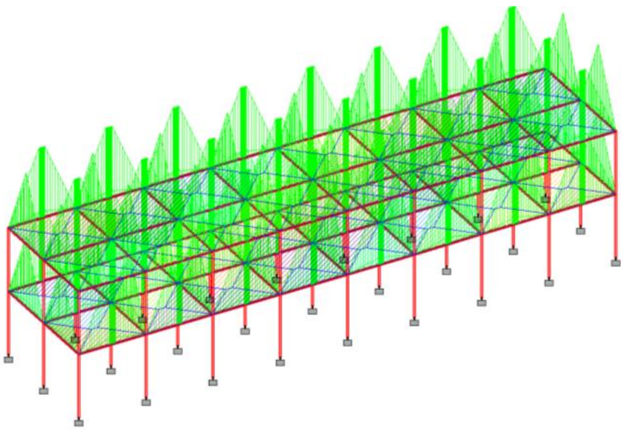

Fig. 2 – Dead load

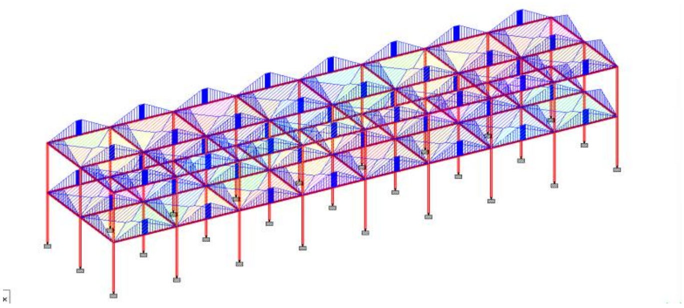

Fig.3 – Live load

5. RESULT AND DISCUSSION

The structure is analyzed using an eight block module in STAADPro software, and the 233tilization ratio comparison of the various channel section combinations is shown in the table below:-

Table -1

Members	Section ISMC150 (C) & ISMC200 (B)	Section ISMC200 (C) & ISMC250 (B)	Section ISMC250 (C) & ISMC300 (B)	Section ISMC300 (C) & ISMC350 (B)
1	0.669	0.773	0.792	0.745
2	0.707	0.630	0.671	0.631
3	0.617	0.617	0.619	0.617
4	0.614	0.615	0.614	0.615
5	0.614	0.615	0.614	0.615
6	0.617	0.617	0.619	0.617
7	0.707	0.630	0.671	0.631
8	0.669	0.773	0.792	0.745
9	0.708	0.658	0.654	0.624
10	0.647	0.637	0.630	0.636
11	0.615	0.619	0.617	0.621
12	0.614	0.615	0.614	0.615
13	0.614	0.615	0.614	0.615
14	0.614	0.619	0.617	0.621
15	0.647	0.637	0.630	0.636
16	0.708	0.658	0.654	0.624
17	4.108	3.684	3.688	3.572
18	7.380	8.576	8.643	3.756
19	8.481	9.203	4.220	3.664
20	8.347	9.303	3.828	3.643
21	8.330	9.298	3.732	3.641
22	8.347	9.303	3.828	3.643
23	8.481	9.203	4.220	3.664
24	7.380	8.576	8.643	3.756
25	4.108	3.684	3.688	3.572
26	1.684	1.624	1.636	1.652
27	3.926	2.172	2.245	1.871
28	2.270	2.058	1.722	1.697
29	2.192	1.996	1.718	1.670
30	2.182	1.952	1.710	1.669
31	2.192	1.996	1.718	1.670
32	2.270	2.058	1.722	1.697
33	3.926	2.172	2.245	1.871
34	1.684	1.624	1.636	1.652
35	0.980	0.878	0.905	0.967
36	0.731	0.716	0.753	0.728
37	0.710	0.708	0.709	0.711
38	0.708	0.708	0.708	0.708
39	0.708	0.708	0.708	0.708
40	0.710	0.708	0.709	0.711
41	0.731	0.716	0.753	0.728
42	0.980	0.878	0.905	0.967
43	0.914	0.773	0.767	0.727
44	0.733	0.718	0.731	0.725
45	0.710	0.708	0.709	0.712
46	0.708	0.708	0.708	0.709
47	0.708	0.708	0.708	0.709
48	0.710	0.708	0.709	0.712
49	0.733	0.718	0.731	0.725
50	0.914	0.773	0.767	0.727
51	4.806	5.378	6.323	4.459
52	6.995	9.754	12.067	6.936
53	6.741	13.504	8.868	6.767

54	6.701	15.149	7.610	6.742
55	6.696	15.612	7.246	6.737
56	6.701	15.149	7.610	6.742
57	6.741	13.504	8.868	6.767
58	6.995	9.754	12.067	6.936
59	4.806	5.378	6.323	4.594
60	2.465	2.728	2.970	2.660
61	2.938	3.747	3.279	2.881
62	2.935	3.201	3.203	2.772
63	2.888	3.612	2.985	2.762
64	2.877	3.753	2.880	2.753
65	2.888	3.612	2.985	2.762
66	2.935	3.201	3.203	2.772
67	2.938	3.747	3.271	2.881
68	2.465	2.728	2.970	2.660
69	0.669	0.769	0.730	0.745
70	0.707	0.668	0.632	0.631
71	0.617	0.618	0.618	0.617
72	0.614	0.614	0.615	0.615
73	0.614	0.614	0.615	0.615
74	0.617	0.618	0.618	0.617
75	0.707	0.668	0.632	0.631
76	0.669	0.769	0.730	0.745
77	0.708	0.654	0.629	0.624
78	0.647	0.629	0.633	0.636
79	0.615	0.616	0.621	0.621
80	0.614	0.614	0.615	0.615
81	0.614	0.614	0.615	0.615
82	0.615	0.616	0.621	0.621
83	0.647	0.629	0.633	0.636
84	0.708	0.654	0.629	0.624
85	3.078	3.18	3.386	2.958
86	4.674	4.413	4.713	3.878
87	4.647	5.13	4.367	3.778
88	4.518	5.753	4.049	3.758
89	4.502	5.7	3.934	3.756
90	4.518	5.573	4.049	3.758
91	4.647	5.13	4.367	3.778
92	4.674	4.413	4.713	3.878
93	3.078	3.18	3.386	2.958
94	2.300	2.495	2.437	2.246
95	2.998	3.679	2.684	2.056
96	3.335	2.966	2.271	1.869
97	3.328	3.040	2.137	1.851
98	3.314	3.064	2.097	1.853
99	3.328	3.040	2.137	1.851
100	3.335	2.966	2.271	1.869
101	2.998	3.679	2.684	2.056
102	2.300	2.495	2.437	2.246
103	0.592	0.606	0.612	0.624
104	0.754	0.695	0.720	0.828
105	0.682	0.7	0.807	0.831
106	0.678	0.702	0.813	0.830
107	0.678	0.702	0.813	0.830
108	0.678	0.702	0.813	0.830
109	0.682	0.7	0.807	0.831
110	0.754	0.695	0.720	0.828
111	0.592	0.606	0.612	0.624
112	0.617	0.653	0.664	0.673
113	0.682	0.775	0.802	0.800
114	0.744	0.784	0.796	0.806
115	0.748	0.786	0.797	0.805
116	0.748	0.786	0.797	0.804
117	0.748	0.786	0.797	0.805
118	0.744	0.784	0.796	0.806
119	0.682	0.775	0.802	0.800
120	0.617	0.653	0.664	0.673
121	0.592	0.603	0.613	0.624
122	0.754	0.694	0.767	0.828
123	0.682	0.743	0.809	0.831
124	0.678	0.747	0.811	0.830
125	0.678	0.747	0.811	0.830
126	0.678	0.747	0.811	0.830
127	0.682	0.743	0.809	0.831
128	0.754	0.694	0.767	0.828
129	0.592	0.603	0.613	0.624
130	0.617	0.651	0.664	0.673
131	0.682	0.774	0.810	0.800
132	0.744	0.793	0.796	0.806
133	0.748	0.795	0.796	0.805
134	0.748	0.795	0.796	0.804
135	0.748	0.795	0.796	0.805
136	0.744	0.793	0.796	0.806
137	0.682	0.774	0.810	0.800
138	0.617	0.651	0.664	0.673

The combination of ISMC 150 and ISMC 200 has the most efficient utilization ratio when compared to the other sections, as can be seen in the above table. Additionally, the ratio decreases as one moves up the sections, but from an economic perspective, ISMC 150 and ISMC 200 are the most efficient and can be used to strengthen the structure in this project.

6. CONCLUSION

In summary, using channel sections as stiffeners in a rehabilitation project can significantly improve the current structure's structural stability and load-bearing ability. It is possible to successfully strengthen important components like beams, columns, and load-bearing walls by carefully incorporating channel sections into the framework. In addition to redistributing loads, this reinforcement minimizes structural flaws, lowering the chance of failure or collapse. Furthermore, the adaptability of channel sections enables tailored solutions to handle certain structural issues, guaranteeing top performance and security. Furthermore, compared to other retrofitting techniques, the installation of channel sections as stiffeners is frequently a more economical and effective solution, minimizing interruption to continuing activities. All things considered, adding channel sections as stiffeners to rehabilitation projects is a dependable and useful way to increase the longevity and structural integrity of infrastructure and structures.

7. REFERENCE

[1] J. Mohan1 C. Selin Ravikumar2 and T.S. Thandavamoorthy3. Using Stadd Pro: Building Design And Analysis, Journal of Science and Technology (JST) Volume 2, Issue 3, May - June 2017, PP 27-33.

[2] Jiří Sedlák*, Petr Jelinek, Zuzana Stránská", Karel Struhala**, Environmental Aspects Of Renovations - Case Studies,6th International Building Physics Conference IBPC 2015.

[3] Charles Thibodeaua,b , Alain Bataillea,⁎ , Marion Siéc,d, Building Rehabilitation Life Cycle Assessment Methodology–State Of The Art , https://doi.org/10.1016/j.rser.2018.12.037 , 16 December 2018

[4] Beata Nowogo´nska, A Methodology For Determining The Rehabilitation Needs Of Buildings, http://dx.doi.org/10.3390/app10113873 , Appl. Sci. 2020, 10, 3873.

[5] Alem R.S Ghdoura1 , Vikas Srivastava2, Analysis of Steel Framed Structure using STAAD Pro and ROBOT Software ,International Journal of Scientific Engineering and Technology Research, Volume.05, IssueNo.07, March-2016, Pages: 1442-1449

[6]Gomasa Ramesh, Design and Analysis of Residential Building using STAAD-Pro, Indian Journal of Engineering, 2021, 18(49), 185-190

[7]A.D.Bhosale, 1 Archit Pradip Hatkhambkar, 2Rupesh Vinayak Katkar, 2 Shubham Balasaheb Babar, 2 Sunny Pramod Gorivale, 2 ; Analysis and Design of Multi-Storey Building by using STAAD-Pro V8i, International Journal of Innovative Science and Research Technology, Volume 3, Issue 4, April – 2018

[8] By T. D. Bush,1 E. A. Jones,2 Behavior Of RC Frame Strengthened Using Structural Steel Bracing, Journal of Structural Engineering, Vol. 117, No. 4, April, 1991

[9] Ikbal Cetiner⁎, Ecem Edis , An environmental and economic sustainability assessment method for the retrofitting of residential buildings , http://dx.doi.org/10.1016/j.enbuild.2014.01.020 , Accepted 9 January 2014.

[10] S.S. Chandar1, Rehabilitation of Buildings, International Journal of Civil Engineering Research ,ISSN 2278-3652 Volume 5, Number 4 (2014), pp. 333-338 © Research India Publications.

[11] Mª. Desirée Alba-Rodrígueza,⁎ , Alejandro Martínez-Rocamorab , Patricia González-Vallejoa , Antonio Ferreira-Sáncheza , Madelyn Marreroa , Building rehabilitation versus demolition and newconstruction: Economic and environmental assessment , http://dx.doi.org/10.1016/j.eiar.2017.06.002 , ; Accepted 11 June 2017

[12] Khalid Heiza, Ahmed Nabil, Nageh Meleka, and Magdy Tayel , State-of-the Art Review: Strengthening of Reinforced Concrete Structures – Different Strengthening Techniques , https://www.researchgate.net/publication/260991475 , · March 2014

[13] 1Mohamed Hamud Mohamed, 2Hanad Muse Ali, 3Abdikadir Hassan, 4Abdiaziz Abdillahi Elmi, 5Abdihakim Liban Abdi, 6Monika Verma , A REVIEWON DESIGN AND ANALYSIS OF MULTI-STOREY BUILDING BY STAAD.PRO , https://www.researchgate.net/publication/353917670 , April 2021

[14] Tejashree Kulkarni1 , Sachin Kulkarni2 , Anjum Algur3 , M. H. Kolhar4 , Analysis And Design Of High Rise Building Frame Using Staad Pro , International Journal of Research in Engineering and Technology , Volume: 05 Issue: 04 | Apr-2016

[15] Andrei M. Reinhorn1, Stefania Viti2 and GianPaolo Cimellaro3 , Retrofit Of Structures: Strength Reduction With Damping Enhancement

[16] by Rui Marques a, Paula Lamegoa,b, Paulo B Lourenço a, and Maria L Sousac,d , Efficiency And Cost- Benefit Analysis Of Seismic Strengthening Techniques For Old Residential Buildings In Lisbon , http://dx.doi.org/10.1080/13632469.2017.1286616 , Published online: 24 Apr 2017.