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A Review of An Examination of Industrial Roof Truss with Or Without Cold Formed Steel Section

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ABSTRACT

This study aims to present an overview of recent advancements in the use, analysis, and design of cold-formed steel buildings over the last five years. Instead of secondary systems, tents, etc., cold-formed steel supporting structures are prioritized. Frames, steel buildings, and racking are the three principal projects for cold-formed steel that are still expanding. To illustrate the application, the examples mostly draw on the author's experience in North America. Cold-formed steel structures can be made from thin sections. Therefore, it is essential to evaluate each step of the process. Significant improvements in structural analysis are both feasible and desirable, at least for thin-walled members, according to recent work on general beam theory and finite band approaches. Structures made of cold-formed steel are always getting better and more precise. New system-wide extensions of a limb and other recent achievements in directed force design methodologies are discussed. Finally, earthquake engineering has advanced significantly in application, analysis, and design, much like many other civil engineering fields. This development is examined for cold-formed steel structures to reflect their present status and potential future directions.

keywords: ETABS, SAP2000, Cold Formed Steel, Hot Rolled Steel, Industrial Roof Truss etc.

I. INTRODUCTION

A structure can be made up of a number of edges connecting a number of vertices. All planar (2D) and residential (3D) trusses and constructions fall within this category. Additionally, masses are positioned at the nodes to provide the structure with forces and moments. In order to prevent the nodes' mass from causing the structure to move or rotate, restrictions are also put on them. To obtain a functional structure for the system, at least six degrees of freedom must be stressed, and high stresses have the tendency to stiffen the structure.

Cold-formed steel

Cold-formed steel is a generic term for products obtained by rolling or stamping steel to produce semi-finished or finished products at relatively low temperatures (cold forming). Cold-formed steel products are manufactured from billets, bars, or plates into products that can be used by shaping, rolling (including roll-forming), or pressing. Since the introduction of the first written standards in 1946, the use of cold-formed structural steel has become widespread. In the construction industry, load-bearing and non-load-bearing components are made of high-quality sheet steel. These construction materials include slabs, columns, beams, posts, and other structural pieces. The structural steel material known as hot rolled steel is distinct from cold-formed structural steel (see structural steel). Products made of cold-formed steel are rolled or pressed at room temperature. Buckling is frequently employed to regulate the strength of construction-related materials. Screws are employed in the construction process, just like they are in the construction of timber trusses, to join the frame to the supporting structure.

Cold-formed steel is being used more and more often all around the world. Low-rise construction, including residential, commercial, industrial, and institutional buildings, is typically built out of cold-formed steel. There are several types of cold-formed profiles that are frequently used. Due to their curved form, these sections are at risk for structural instability. Local, lateral, and lateral torsional buckling are all types of sectional buckling that can occur in C-section and Z-section beamsCold-formed features frequently contain reinforced edges on the flanges and centre ribs on the broad and web flanges. They can be symmetrical or asymmetrical in design. These qualities of this section's point of symmetry are typical of bisymmetric sections, including Pipe sections or B.I. profiles. Better stability from hot-rolled I-beams is combined with a high strength-to-

weight ratio from conventional cold-formed profiles like C-beams and Z-beams.

Better cold-formed steel profiles had previously been developed by the investigators and can now be created utilizing current industrial cold-formed steel procedures. Now, it is possible to combine two or more pieces to create a complex structural shape. The use of high-strength steel, which delivers greater strength, necessitates a reduction in thickness but has the advantage of allowing the combination of various material classes and thicknesses in one piece. The structure may become unstable if the joints are weak. The structural features of frequently used cold-formed billets have been extensively studied. However, there hasn't been much study done on how other cold-formed steel member types perform structurally. Therefore, it is urgently necessary for the cold-formed steel sector to develop novel or inventive cold-formed profiles in addition to traditional cold-formed steel. When it comes to structural steel beam profiles, they are very effective and affordable.

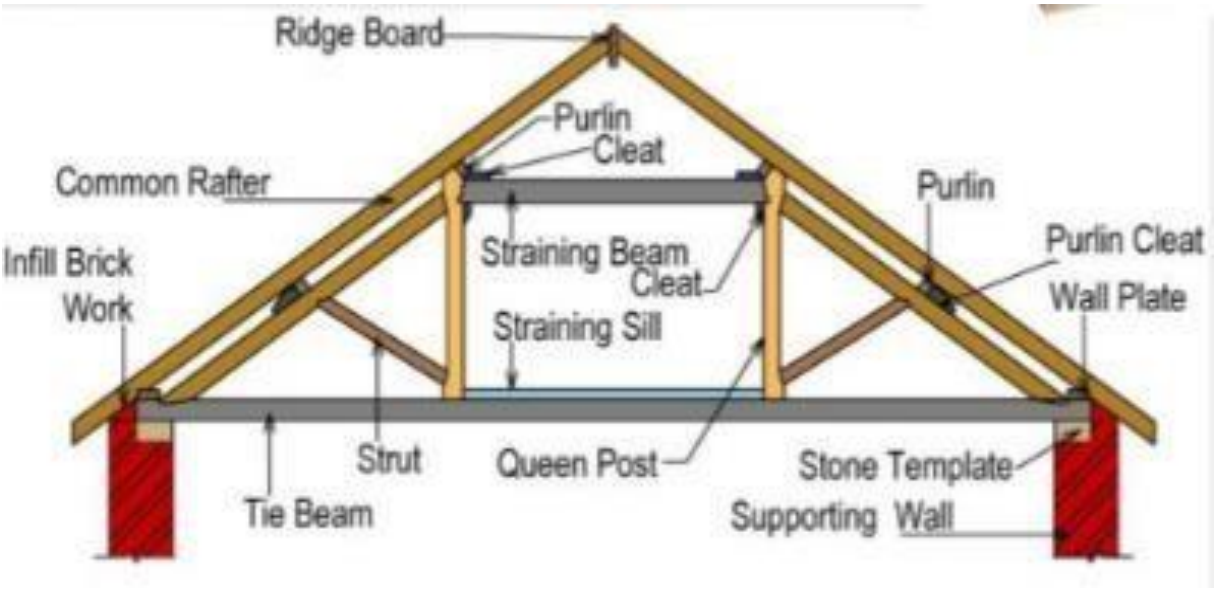

Fig. 1 Members of truss

Hot Rolled Steel

In the hot rolling process, steel is rolled at temperatures above its point of recrystallization (often above 1700°F). Steel is easier to form and shape when it is above the recrystallization temperature, allowing for greater sizes. Due to the fact that hot-rolled steel is typically manufactured right away, it is less expensive than cold-rolled steel because it does not require reheating as does (cold-rolled steel). When steel cools, it somewhat contracts, making it more challenging to manage the final size and shape than when it is cold rolled. The welding and construction industries use hot-rolled goods, such as hot-rolled I-beams and stiffeners. Where perfect forms and tolerances are not necessary, hot-rolled steel is used.

Cold Rolled Steel

Cold-rolled steel is basically cold-rolled steel that has been further processed. The steel is then processed in a cold rolling mill, where the material is cooled (to room temperature) and then annealed and/or cold rolled. This process produces steel with tighter dimensional tolerances and a wider range of surface finishes. The term "cold rolled" is used loosely for all products, although the product name refers to both sheet-rolled and flat-rolled products. Bar products are called "cold worked" and usually involve cold drawing and/or turning, milling, and polishing. This process raises the yield point and has four main benefits:

1. Cold drawing increases the yield and tensile strengths, often eliminating further costly thermal treatments.
2. Turning gets rid of surface imperfections.

3. Grinding narrows the original size tolerance range.
4. Polishing improves surface finish.

All cold products provide a superior surface finish and are superior in tolerance, concentricity, and straightness when compared to hot rolls. Cold-finished bars are typically harder to work with than hot-rolled bars due to the increased carbon content. However, this cannot be said about cold-rolled sheet or hot-rolled sheet. With these two products, the cold-rolled product has a low carbon content and is typically annealed, making it softer than hot-rolled sheet. Any project where tolerances, surface condition, concentricity, and straightness are the major factors

Fig. 2 Different types of cold formed steel section

II. LITERATURE REVIEW

Sulendra, et al. (2023).

In this study, we look at the earthquake-damaged wooden roof structures of existing buildings as well as other types of damage. Compare alternate plans for wood roofing and roof structures that are both new and restored. The restored wooden roof features a half-timbered 70x70x6 roof with sides that are each 70x70x6, as well as a 250x125 WF gable structure with a span of 15 metres and a 45° slope. According to a preliminary analysis of the timber structure, numerous components and nodal joints connecting the wall and frame had been damaged because of inadequate connection methods. The redesigned timber roof, gable roof, and gable roof structure had increased strength, stiffness, and strength-to-weight ratio.

Ahiwale et al. (2023)

The seismic performance of reinforced concrete structures using various bracing techniques is compared in this study. The types of braces taken into consideration include Inverted V-Clamp Frames (IVBF), V-Pinch Frames (VBF), X-Pinch Frames (XBF), Diagonal Clamp Frames (DBF), Three-Piece Clamp Frames (TMGBF), Modified Inverted V-Clamp Frames (MIVBF), K-Brace Frames (KBF), and Z-Brace Frames (ZBF). SAP2000 software was used to develop and assess a reinforced concrete 10-story building with ground floor heights of 3.5, 4, and 4.5 metres. An analysis of time and pressure that is nonlinear was done. Steel posts are located in the middle of each of the frame's three bays that run in opposite directions. The load-bearing curve, displacement speed, total damage index, floor-to-floor displacement speed, base thrust, floor displacement, number of hinges, plasticity, and history of roof displacements all serve as indicators of the building's structural response.

Rahane, Shraddha Nilesh, and S. K. Nalawade. (2022).

This study aims to explore Warren steel frames utilizing various Pratt & Howe steel frames, optimize them, and analyse Warren and Pratt & Howe steel frames. The present structure's steel beams were designed to reduce weight and achieve disproportionately high loads and deflections. The truss's cross-sectional area is seen as a variable force. The schedule optimizer tool in ANSYS is used as the main optimisation method to lengthen and optimise the steel beams such that they best meet pure truss calculations for the least weight. Response

convergence is ensured by combining all ANSYS finite element models. Consider the minimal safety distance of each truss element while comparing different trusses.

Paswan, S., & Rathore, M. (2022)

In the construction sector, mild steel is a frequently used material. Its primary goal is to construct the frame framework, which holds and connects everything else in the building. One of the most eco-friendly materials is metal, which is also entirely usable. The forces brought on by the earthquake are what have primarily changed the building's construction. The necessary design requirements could not have been accomplished by using conventional ISMB steel components, particularly in severely loaded buildings where moment of inertia and cross section are crucial aspects. The developed structure makes it simple to construct a permanent structure since reinforced concrete profiles can bear even heavy loads. However, with a maximum erection height of roughly 50–60 metres, the concrete pouring method is ineffective. But as with anything new, technology also has its share of issues.

Dhiraj Ahiwale et.al. (2021)

Trapezoidal frames are often efficient and economical for long periods in industrial buildings. This study uses seismic excitation in eight regions for numerical analysis to describe the vertical ground motion (VGM) response of a 25 m long and 9 m high trapezoidal grid. VGM and seismic load coupling were analyzed linearly. From the ATC63 specification, eight closest ground seismic records were selected from the PEER NGA database: four with bins and four without The response of the structure was observed using various parameters, such as the bending moment of the foundation, the axial load of the sub-frame, the axial force of the column and the vertical deformation of the truss at the ends. Therefore, SAP 2000 was used to perform a temporal analysis of ground acceleration and stop and go. This study shows how the response of very long frames depends on the vertical component of the ground motion. This study suggests that an analysis of the time and vertical component of ground motion should be considered when evaluating structures in the near earthquake zone, rather than assuming 2/3 of the maximum vertical acceleration recommended in most coupons.

Jitendra Choubisa et.al. (2020)

In this study, different steel structures were described, analyzed and developed and the results of the ETABS and STAAD pro software were compared. The Indian standard steel specification IS 800: 2007 was considered during the design process. Only vertical loads are considered here, as towers and moving elements (such as the truss in this example) support the road load. In STAAD pro, weight includes dead weight or dead weight, because ETABS calculates the dead weight of a structure and takes the dead weight first. Both STAAD and ETABS follow LSD (Strategic Goals). The program compares the downtime, shear strength and key response of each system's test components. Both methods give similar results, but ETABS STAAD pro is better. This is because the information obtained is more accurate and the answers are reported in a shorter time. The results of these studies can be used in foundation planning to reduce the need for foundation support.

Jesus J. Yanez-Borjas et.al. (2020)

This study explores STF analysis as a potential method for determining the condition of 9-span 3D trusses excited by electrodynamic forces. To determine the most discriminating statistics for time signatures (STFs), this study analyzed 17 STFs using the Kruskal-Wallis (KWM) method. Three levels of corrosion were analyzed through extensive research to determine the validity of the proposed study. The diameter of the bridge fragments is intentionally reduced to 1mm for initial damage, 4mm for moderate damage, and 8mm for heavy damage to reach this level (severe damage). The configuration decision tree (DTC) is then used to determine which registry items are best for determining the status of the configuration. The results obtained show that the Root Mean Square (RMS) and Root Mean Square (SMR) characteristics are non-linear metrics useful for identifying damage when external corrosion damage occurs to the bridge trusses using DTC of the complex soil. The authors studied triaxial vibration for analysis. The results show that the scheme can detect damage from the closest damage condition. Only one serial installation is required to achieve 100% accuracy.

Rehman, M., & Sakalle, R. (2019)

Due to a growing global population and decreasing resources, there is an increasing demand for structural systems that are more efficient in order to create sustainable economies and communities. Due to their low weight, quick construction time, recyclability, and durability, cold-formed steel framing systems (CFS) are increasingly used as primary or secondary structural elements in modern building construction. However, the strength and ductility of CFS elements are relatively poor due to the low column strength in thin sections, which restricts their performance in tall buildings and under large loads. Prefabricated steel frame construction is a feasible and effective replacement for conventional buildings and basic models in several industries because it has significant advantages over single-story buildingsIn order to support initiatives, prefab buildings develop and manage data-rich multiple points of view in real time. The design and engineering software Staad Pro is now being used to do this.

Giuseppe Quaranta et.al. (2019)

This analysis considers a steel frame design with a hood. This structure is similar to the one reported by Wu and Xiao. Construction systems and small and medium-sized bridges are the main function of this system, especially the roads. Glubam is used to form the top and crossbeams of the rope and Rebar is used to form the bottom of the rope. Load capacity is increased by using full profile sections with high inertia values. Each of these spatial structure systems is constructed using metal joints. Two types of connections are made for the upper and lower wires, depending on the number of channels and the number of probes. By examining the independent damping response, the natural frequency and damping ratio of the first and second vibration modes can be determined. After careful analysis of the experimental data, a constant viscosity modulus of about 1.5% is proposed for the lowest condition (ring condition) of the steel-bonded lattice structure, and the sedimentation value is between 0, 5% and 1.5% (1.5%). The average) should be 1%) recommended for all models.

Dar, M. A., Yusuf, M (2015)

Cold-formed steel sections are widely used in the construction industry today. However, the cross-sectional behaviour of cold-formed, thin, high-strength steel, characterized by different bending modes, is not fully understood. The most commonly used cold-formed beam profiles are C-shaped and Z-shaped because they are easy to form and convenient to join. However, both sides have a certain folding method. In order to significantly improve the strength and stiffness properties of the cross-sectional structure of cold-formed beams, it is necessary to slow down or completely eliminate the various buckling modes. The various cutting-edge transverse profiles and reinforcing configurations for cold-formed steel beams are described in this paper. These novel cold-formed profiles now have a much higher load-carrying capacity and stiffness due to their success in postponing or eliminating numerous premature buckling modes. Beams are frequently made of cold-formed steel.

Bamaga, S. O, et al. (2013)

Structures created from cold-formed steel are manufactured from structural steel sheets or coils using cold rolling, mechanical bending, or hardening. Due to their low weight, ductility from cost-effective cold forming, and good strength-to-weight ratio, these structures are frequently employed in the construction sector. Construction expenses can be greatly decreased by combining steel and cold-formed concrete. Using composite beams constructed of filled concrete and open or closed cold-formed steel boxes can also save on construction expenses. Cold-formed, lightweight composite steel bridge beams in the shape of a u have been developed. Furthermore, an adhesive anchor type is added to produce an adhesive effect between the concrete slab and the cold-formed steel beam. With the addition of cold-formed steel sections and ductile adhesive anchors, further research is advised to examine the impact of metal decking on the behaviour of composite beams.

Gad, E. F., Duffield (1999)

The primary findings of a national study on the performance of cold-formed steel structures are presented in this paper. This research project's major goal is to assess how well these structures perform and behave when

subjected to seismic loads. In-depth dynamic and rack testing of 2D and 3D frame setups are included in this study. Different design elements were put to the test in order to pinpoint crucial elements and gauge the contribution of non-structural elements, particularly the plasterboard cladding. It was determined that the steel construction works admirably under earthquake loads. B. Plasterboard panels greatly boost the lateral support of the frame as non-structural components. The identification and discussion of failure modes and load balancing between various components are also included.

III. FINDINGS

- Discuss the many reasons why the damaged timber roofs on the existing buildings occurred following the earthquake. The roof structures' different designs as well as the existing and retrofitted timber roofs will be compared. [1]
- Examines how different bracing systems and RC constructions behave seismically. The types of braces under consideration include inverted V-braced frames (IVBF), V-braced frames (VBF), X-braced frames (XBF), diagonally braced frames (DBF), three-member gate braced frames (TMGBF), modified inverted V-braced frames (MIVBF), K-braced frames (KBF), and Z-braced frames (ZBF). [2]
- To choose the best truss arrangement for a specific 30m span, compare these trusses. For all configurations, the length of the bottom chord members of trusses is adjusted while keeping the overall truss height, inclination angle, and span, length of the structure, spacing, and external load constant. Tekla software has been used to do the analysis. [3]
- By comparing the minimum margin of safety across all truss members, a truss comparison was made. [5]
- Using eight near-field seismic excitations, describe how a 25 m long, 9 m tall trapezoidal truss structure responded to vertical ground motion (VGM). Combinations of earthquake loads, including VGMs, have been subjected to linear analysis. [7]
- The use of statistical temporal features (STFs), which are recovered from the unprocessed vibration signals of truss-type bridges during dynamic stimulation, is investigated for determining the health of these structures. The most discriminating STFs are then identified using the Kruskal-Wallis method (KWM), and the best ones are chosen for detecting the state of the structure using a feature selection criterion. [9]
- Utilizing the analysis tool Staad.pro, the design industry compares a revolutionary cold-formed steel structure to standard steel products offered on the Indian market. Here, the author will compare a structure's weight and strength using welded and bolted connections. [12]
- A 12 m span hybrid truss was designed using glubam utilised as the upper chords and web members to demonstrate bamboo's effectiveness as an engineered material for large-span buildings. [13]
- When compared to traditional cold formed steel sections commonly used for beams, various innovative sectional profiles and stiffening arrangements for cold formed steel beams would significantly increase the load carrying capacity and stiffness characteristics of such sections. These innovative cold formed sections would successfully contribute in delaying or eliminating various modes of premature buckling.[15]
- In-depth racking and dynamic testing on two- and three-dimensional framing configurations were part of the study project. To determine the crucial elements and evaluate the contributions of the non-structural elements, particularly the plasterboard lining, a range of construction details were evaluated. [18]

S. no	Author Name	Experimental Work	Software
1	K. Sulendra, G. Turu'allo, and APN Siregar(2023)	Setting Up of Tensile and Compression Timber Test Materials, Setting-Up Test and Tensile Curve of Steel	
2	Dhiraj D. Ahiwale · Denise-Penelope N. Kontoni, Prachi L. Darekar(2023)	Pushover analysis, twenty-seven ten-storey 3D reinforced concrete building frames Time-history analysis,	SAP2000
3	Debarshi Sahoo Soham De and Purnachandra Saha (2022)	comparison of Different configuration of industrial truss, based on number of divisions of bottom chord,	Tekla software
4	Tran-Hieu Nguyen , Quoc-Cuong Nguyen, Nhu-Hoang Nguyen, Van-Cuong Nguyen, and Anh-Tuan Vu(2022)	Numerical Modeling, finite element (FE) analysis, Collapse of the Roof Structure	SAP2000
5	Shraddha Nilesh Rahane, S. K. Nalawade (2022)	ANSYS finite component models, Structural Analysis of Pre and Post Optimization of Truss Members	ANSYS
6	Sudhir Paswan, Manas Rathore (2022)	multi-story building models analysis using staadpro	STAAD.Pro ,AutoCAD, Codebook
7	Dhiraj Ahiwale · Prajkta Shaha · Kamatchi Palaniyandi · Chittaranjan Nayak Rushikesh Khartode, Samadhan Morkhade(2021)	Vertical seismic excitations · Long-span trapezoidal truss · Linear analysis · Non-linear dynamic analysis ·	SAP2000
8	Jitendra Choubisa(2023)	Comparison of BM, SF & Reaction, Tower, truss and bridge model analysis	Etabs, STAAD.Pro
9	Jesus J. Yanez-Borjas, Martin Valtierra-Rodriguez, David CamarenaMartinez, Juan P. Amezquita-Sanchez(2020)	Statistical time features, Kruskal-Wallis method, Decision tree classifier	

10	Ronald G. Knapp, Terry E. Miller, and Jie Liu(2020)	Corridor bridges, Covered bridges, Heritage tourism, Langqiao, Rural tourism, Vernacular architecture	
11	K. Narendhar,CH. Rajesh(2022)	Specified loads and/or external impacts.	STAAD.Pro
12	Mufaiz Rehman, Rashmi Sakalle(2019)	Cold-formed steel Structural systems, Cost Analysis, Axial Shear And Torsion Forces.	STAAD.Pro
13	Zhi Lia,□, Tao Lia, Can Wanga, Xiaozhou Hea, Yan Xiaob (2019)	steel-glued laminated bamboo (glubam), Load-carrying test of the truss, Test on glubam members,-displacement & strain curves	Building Information Model (BIM)
14	Giuseppe Quarantaa, Cristoforo Demartinob, Yan Xiaoc(2019)	Dynamic identification, glubam-steel truss structure, Spatial geometry, and Vibration performance	
15	M.A. Dar, M. Yusuf , A.R. Dar and J. Raju(2015)	Innovative sections for cold formed steel beams, buckling modes; cold formed steel; failure modes,tensile test, U.T.M	
16	S. O. Bamaga, M. Md. Tahir, T. C. Tan, S. Mohammad, N. Yahya, A. L. Saleh, M. Mustaffar, M. H. Osman, A. B. A. Rahman(2013)	Cold-formed steel (CFS) structures, composite beam consisting.	
17	Benjamin W. Schafer, druckfrei, nach Korrektur druckfrei(2011)	Cold-formed steel structures, CFS membersNorth America include the C (with and without lips), the Z (typically with sloping lips), and a variety of generally “hat-shaped” deck sections, and GMNIAanalysis	
18	E.F. Gad C.F. Duffield, G.L. Hutchinson, D.S. Mansella, G. Stark(1999)	Comparison of swept sine wave and racking stiffness, domestic structures with cold formed steel frames	

IV. OUTCOMES

- A field assessment demonstrated that the joints of the timber roof trusses had failed. Members under tension load experienced shear failure as a result of inadequate connectors at the joints. The lateral deflection at the joint was brought on by the member under lateral load. The horizontal displacement occurs at the region's Roof to Wall Connections (RWCs). These wooden roof trusses were retrofitted with additional connectors at the joints, and numerous connectors—possibly double and triple steel grip connectors—will be advised for these wooden roof trusses.[1]
- Compared to other braced frames, the XBF is favored for enhancing the structure's overall seismic performance. The TMGBF performs less well than other types of bracing, making it an unsuitable choice for constructions designed to withstand earthquakes. [2]
- When optimised, the Warren truss exhibits a high stiffness to weight magnitude relation compared to other trusses. [5] The reaction of the long-span roof truss frame can be significantly influenced by the vertical component of ground motion.[7]
- The choice of software—the veteran STAAD or the up-and-comer Etabs—depends on the individual because Etabs received fewer negative comments than STAAD overall, although both programmers essentially perform the same tasks. [8]
- According to this study, cold-formed steel is more effective at withstanding ions, loads, and unbalanced forces. This leads to the conclusion that C.F.S. sections exhibit significantly less deflection. One can reduce the cost by 14% of the total cost by employing C.F.S. since torsion and support reaction are relatively less in C.F.S. [12]

- A novel composite glubam-steel's dynamic properties Truss structure of glued laminated bamboo (glubam) for the upper chords and diagonal bars and steel bars with hollow cross sections for the lower chord bars. [14]
- The self-weight of a hot-rolled section increased by about 3 to 5.5 kg/m length when it was designed for the same load carrying capacity, proving that the goal of replacing conventional hot-rolled sections with creative cold-formed steel sections was achieved. [15]
- In conventional reinforced concrete beams, composite-filled concrete beams, and composite beams, efforts have been made to employ and confirm the use of CFS section as a replacement for the traditional reinforcement bars.
- Typical composite beams and bridge girders. Generally speaking, CFS sections of a traditional composite beam could be used to reach the required strength capacity. The ductility requirement is still not sufficient, though. Future research on this subject is thus advised. [16]
- Under earthquake loads, the steel frames function very effectively. Plasterboard lining and other non-structural elements play a large role in the lateral bracing of the frames. [18]

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