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Cold formed steel structure: An overview

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ABSTRACT

Nowadays, the application of cold formed steel elements in construction is becoming very popular due to several advantages like Speedy construction, higher strength to weight ratio, dimensional stability and recycled material. Besides, cold formed steel section has some undesirable properties that create challenges for its use in construction. The very small thickness makes it vulnerable to the different type of buckling, web crippling, torsional failure and also susceptible to fire. To overcome these challenges and utilize the advantages of cold formed steel element by improving its properties, important research works are being carried out all over the world. There are guidelines and specifications available in different codes of cold formed steel structure and it makes engineers confident in the application of cold formed steel elements in construction. The objective of this study is to represent an introduction of cold formed steel structure by reviewing the behavior, material properties, production methods, classification of cold formed steel elements. It also discusses the codes and guideline available for cold formed steel structure, important design criteria, connection, methods and durability issues based on some excellent researches.

Keywords: Cold formed steel, Connection, Durability

1. INTRODUCTION

Steel as a structural material has become the perfect choice in the construction sector for its innumerable advantages over other building materials. Steel used in the construction mainly categorized into two families as hot rolled shapes member and plates and other is cold form

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steel. Although first one is the most familiar, various benefits of cold formed steel are growing interest in both the research and construction sectors especially in Industrialized Countries, like USA, Canada, Australia and some European Countries. In the construction of low-rise residential building, transmission towers and commercial building cold-formed steel is being used as a structural element. It is also being used in the construction of bridge, storage and drainage facilities, bins etc. This paper presents the applications of cold formed steel structure in building construction based on some excellent reference. Most commonly in case of building construction, cold formed steel members are used as a secondary structural element. But recently the application of cold formed steel has increased in buildings for its inherent features like higher weight to strength ratio, adaptability, non- combustibility, and easier production process. The architects are encouraged by these advantageous properties of cold formed steel structures and aesthetic appeal. Due to good structural performance and economy, it is also a good choice for engineers, contractors, and owners. Cold formed steel products are the composition of plane steel sheets or plate, that conforms the structural requirement and produced at ambient temperature by the operation of machines, press brake or bending brake. Generally in cold formed steel structure, the plates and bars having the thickness of 25.4 mm can be converted into cold formed steel element. In spite of having advantages like economic production, easy transportation, low labor costs, higher strength-to-weight ratio, Cold Formed Steel sections involves complex behavior and problems like more slenderness and local, distortional and coupled instability phenomena. To reach deep inside these properties and find appropriate modifications in models, specifications, and code, researchers did many important studies regarding the complexity of cold form steel [1-3].

The structural behavior of steel depends on its chemical composition and the process of manufacturing. In case of hot-rolled steels, Mechanical properties of normal and increased temperature are provided by design standards accurately. But due to the forming process the mechanical properties of cold-formed steels vary from hot-rolled steels. The forming procedure of cold formed steel generally increases the yield and ultimate tensile strength and reduces the tensile elongation capacity of cold formed steel. The various cross sections for cold formed steel is available and cross section is also a factor that influences the mechanical properties of cold formed steel. Three facts are considered to be the basic reasons behind this changing of mechanical properties of cold formed steel during its cold-forming process and they are strain aging, strain hardening, and Bauschinger effect. Strain hardening is one kind of strengthening of steel due to the rearrangement in materials cristal by plastic deformation. Strain aging is the increase of maximum load carrying capacity of steel when it is subjected to aging after it is stressed in elastic range. Bauschinger observed such phenomenon in (1887) [4].

Various advance researches revealed that Strain-ageing increases both the yield and ultimate tensile strength of steel sections and reduces the tensile elongation capacity or ductility. Figure 1 shows the typical stress-strain curve for steel in different condition. Actually the strain hardening and strain aging are the two major reasons behind the effect of the cold-forming process on the mechanical properties of steel. From this Figure 1, it is observed that if the steel is pre-strained and then this is subjected to aging, the yield strength and the tensile strength are increased, but the elongation or ductility is reduced.

At elevated temperature, the key mechanical properties like the modulus of elasticity and yield strength of cold formed steel are affected and control the behavior of cold formed steel structure against fire. Due to affected mechanical properties at elevated temperature, the cold formed structural elements become more susceptible to buckling. Important codes and guidelines consider the effect of fire on cold formed structures like for mechanical properties of cold-formed steel, BS 5950 Part 8 (1990) and the EN 1993-1-2:2005 (2005) consider reduction factors as increasing temperature. This reduction factor should higher for CFS element than that of hot rolled steel because of the effects of molecular surface metallurgical composition.

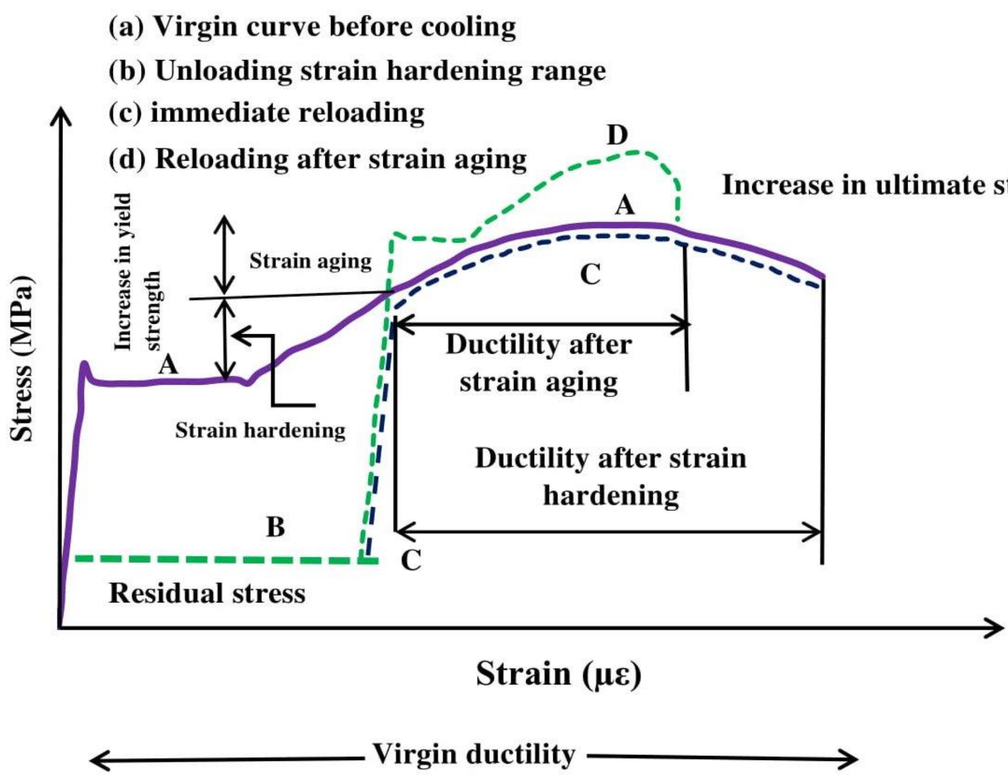

Figure 1. Effects of strain hardening and strain aging on typical stress-strain characteristics of structural steels.

2. MATERIAL PROPERTIES

Material properties have great influence in a structural application of cold formed steel structures. From a structural standpoint, the behavior of components like steel sheets, plate are very important and properties like Yield and Tensile strength, Fatigue strength, Stress-strain properties, Modulus of elasticity, tangent, and shear Modulus, elongation capacity, Weldability, durability, Toughness must be considered to ensure their proper use.

The yield strength of steel represents the strength of cold-formed steel structural members except for a few cases like connection system and where elastic buckling is critical. North American specification provides a list representing the yield stresses of steels which ranges from 24 to 80 ksi. The stress strain curves of cold formed steel element is different from hot rolled steel element. For hot rolled steel, It is the sharp-yielding type and the level at which the stress-strain curves seems to be horizontal that the yield stress is specified. For cold formed steel, gradual-yield is observed on the stress-strain curve. And to find the yield stress two major methods named as the offset method and the strain-under load method is used by rounding out the curve at the "knee" [5].

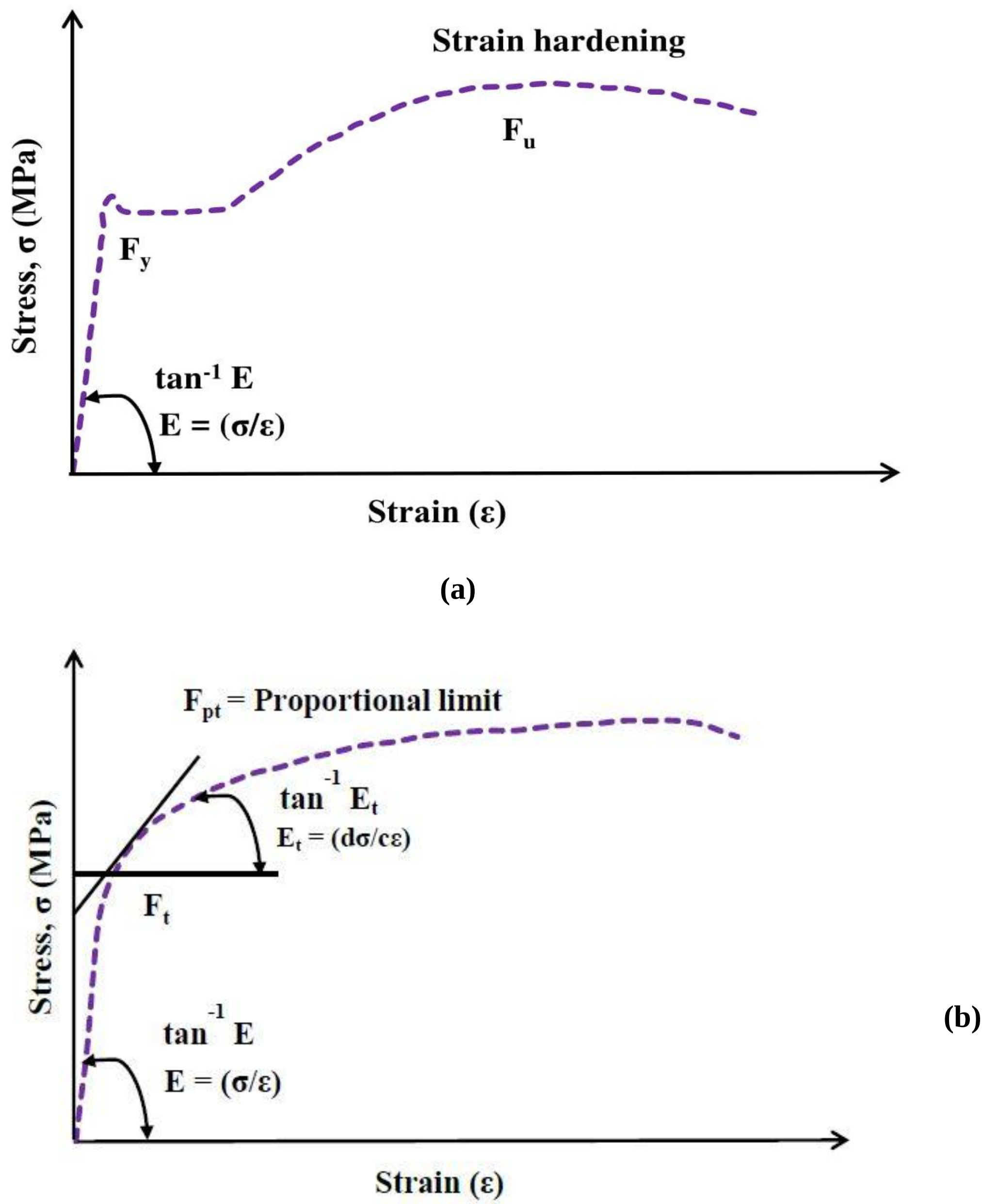

Figure 2. Typical stress-strain curves for carbon steel sheet or strip: **(a)** sharp yielding, **(b)** gradual yielding.

The importance of Tensile strength is less for cold formed structural section when it is subjected to flexure and compression because in this case yield stress and buckling stress is considered to be more important. In case of flexural and compression members, yield stress or buckling stresses are more important than tensile stress. But for sections used as the connection or subjected to tension, tensile strength is an important material property. For these kinds of situation, codes like North American specification gives design provision for considering the ultimate strength of steel. It provides the list of minimum tensile strengths which ranges from 290 to 690 MPa or 2953 to 7030 kg/cm^2 and The ratios of tensile strength to yield stress, F_u/F_y ranges from 1.08 to 1.88.

Ductility is very important properties of steel especially in case of structural application. It can be defined as the condition of the material when without being raptured, it can sustain plastic deformation. Ductility is much desired property for the production process and for redistributing the stresses in a structural element which can be subjected to stress concentration. There are different kind of tests to find the Ductility of a structural element such as tension test, notch test or bend test. Ductility is measured as the permanent elongation of these tests.

Due to manufacturing and fabricating processes, the structural elements have some stresses which are called residual stresses. For hot rolled Studies have shown the effects, distribution, and influence on load carrying capacity. In case of cold formed steel, the residual stresses involve with the cold rolling and cold bending during production. The influence of this residual stress on stress-strain curve is expected to be similar to cold formed steel to hot rolled steel.

3. PRODUCTION METHODS

Main methods generally used in the manufacturing process of cold-formed sections are Cold roll forming, Folding and press braking. Cold formed structural element like individual member, wall section, roof panel, corrugated sheets etc. are produced by cold rolling method. Structural element produced from cold rolling method considered to be more economical if these can be made from 36 in. (915 mm) wide strips and 3000 ft (915 m) long coils. In this process, the machine uses pairs of rolls that keeps forming strips with the desired shape. In case of cold formed element with a simple shape such as roof sheet, decking sections etc. where the press brake can be used. The equipment used in the press brake method, a top beam moves over a stationary bottom bed having the dies for the desired product as shown.

4. CLASSIFICATION

Different kinds of cold formed steel sections are used in a structure for different purposes. But for structural use, the application of cold formed steel can be seen mainly as framing members like beam, column and truss member and as flooring system. The Cold-formed steel structural elements used as structural framing members have a different cross section, thickness and properties compared to the elements used as Panels and decks.

4. 1. Individual Structural Framing Members

Individual Structural Framing Members may have the shape like channels (C-sections), Z-sections, angles, hat sections, I-sections, T-sections, and tubular members etc. Lipped C and Z sections are considered to be the most common sections with thickness vary from 1.2 mm to 3.2 mm [6].

According to various studies, sigma section is beneficial for its high load-carrying capacity. Sigma section has torsional rigidity higher than standard channels. It is light in weight and has a smaller blank size. The performance of cold formed steel section varies with grade, slenderness ratio, temperature etc. and is a popular field of research. Actually, the use of plain 90" angle, 60" angle, lipped 90º angle T-section, back-to-back lipped channel sections are advantageous for the construction of transmission tower for their axial load capacity.

4. 2. Panels

Besides framing member cold formed steel is also used to provide flooring system, roof system, and wall system. Cold formed steel Panels and Decks of different geometry are used in these systems. These elements of cold formed steel are also used to create a space for concreting. These elements are also used to provide duct facilities for air conditioning, electrical and heating system. They are also used to arrange sound absorption material properly. In case of application of a deeper panel, to increase the stiffness of these sections intermediate and edge stiffeners needs to be used. The depth and thickness of these cold formed steel panels generally vary from 20 to 200 mm and 0.4 to 1.5 mm respectively.

5. CODES AND SPECIFICATIONS

The application of cold formed steel elements was greatly challenged in 1930 because design guideline was not available at that time. The behavior of cold formed steel is different from the hot rolled steel for various reasons such as the difference in geometry, weight, forming methods, connection etc. Popular building codes didn't have detail provisions for such lightweight steel elements during that time. In those circumstances, the desire for new design codes and guidelines for cold-formed steel construction was salient. In 1939, at Cornell University, a committee of The American Iron and Steel Institute (AISI), established in 1855 promotes a research project, to collect necessary information especially for design guidelines for cold formed steel. George winter is called "the father of cold formed steel".

He continued his work on cold formed steel at Cornell until 1975 before his retirement. The first four research works of George winter (1940, 1943, 1944, and 1946) for AISI were very important for the light gauge steel structure. AISI had published the specification for the design of light gauge steel structural members, first edition (1946) by gathering these research works of George winter. In United States, Besides the Cornell work, there are many organizations and universities involved with various research works on properties, connection, and newer structural element of cold-formed steel [7]. The first edition of "Specification for the Design of Light Gage Steel Structural Members" issued by the AISI in 1946 was allowable stress design (ASD) specification. To include the further developments in this field, the further revision was made by the AISI committee in 1956, 1960, 1962, 1968, 1980, and 1986 incorporating some important findings from researches. In 1991, AISI issued the first edition of the load and resistance factor design (LRFD) specification and in 1996, a specification combining the ASD and the LRFD Specification were issued.

The detail information regarding the revisions of different editions of the AISI Specification was discussed in American Iron and Steel Institute, 1996 [8]. In 1963, based on

AISI Specification edition 1962, Canadian Standards Association (CSA) issued the first design specification for structural use of cold formed steel in Canada by bringing some minor changes. The later editions were published in 1974, 1984, 1989, and 1994.

The AISI specification was always followed in Mexico for the design of cold formed steel structure. In 2001, North American Specification (NAS) was developed. The first design manual for the Light Gauge Steel was published by AISI in 1949 and modified in 1956, 1961, 1962, 1968–1972, 1977, 1983, 1986, 1996, 2002, and 2008. The additional publication of AISI is "Overview of the Standard for Seismic Design of Cold-Formed Steel Structures—Special Bolted Moment Frames, Direct Strength Method (DSM) Design Guide, Cold-Formed Steel Framing Design Guide, Steel Stud Brick Veneer Design Guide. Furthermore, an organization like Steel Engineers Association (LGSEA) and Cold-Formed Steel Engineers Institute (CFSEI) of the Steel Framing Alliance provides important technical notes.

6. DESIGN CONSIDERATIONS OF COLD-FORMED STEEL

There are differences between the production process of cold formed steel and hot rolled steel and due to this dissimilar production process, the structural behavior of them is also different. Also, the smaller thickness of cold formed steel makes its behavior different from hot rolled steel. The design criteria regarding buckling, torsional rigidity, Web Crippling, Bending Strength and Deflection of cold formed steel are different from hot rolled steel.

6. 1. Buckling

The thickness of Cold formed structural steel sections are very thin compared to its width. This property makes these sections susceptible to buckling. When compression, shear or bearing is applied to these cold formed members, they can buckle before yielding. So, buckling is one of the most important design criteria to be considered in case of cold formed steel members. Four types of buckling can be seen in these members, such as local buckling, global buckling, distortional buckling, and shear buckling. Local buckling is the buckling of the individual element having buckling wavelength relatively short. Global buckling is generally observed in columns and beams and without showing any cross sectional distortion, the member undergoes buckling, such as flexural buckling and lateral torsional buckling [9]. In case of distortional buckling the distortion of cross section of the member happens and its wavelengths state is intermediate of global and local buckling. These different types of buckling can also interact with each other.

6. 2. Torsional Rigidity

Torsional rigidity of an open section depends on the thickness and proportional to the cube of its thickness. As cold formed members have a very small thickness, so it is vulnerable to torsion. A beam with channel-shaped is shown in Figure 3, which twists when the load is applied to the plane of its web. It can be seen that the shear center exists outside of the web and the rotation is initiated by the applied load. The torsional-flexural buckling of cold formed structural compression element can be a very critical factor. This can happen because the cold-formed steel elements have a relatively lower thickness and when sometimes the centroid of the section and the shear do not coincide. Furthermore, in some cases of cold formed beams or columns distortional buckling can be an important factor and govern the design criteria for such members.

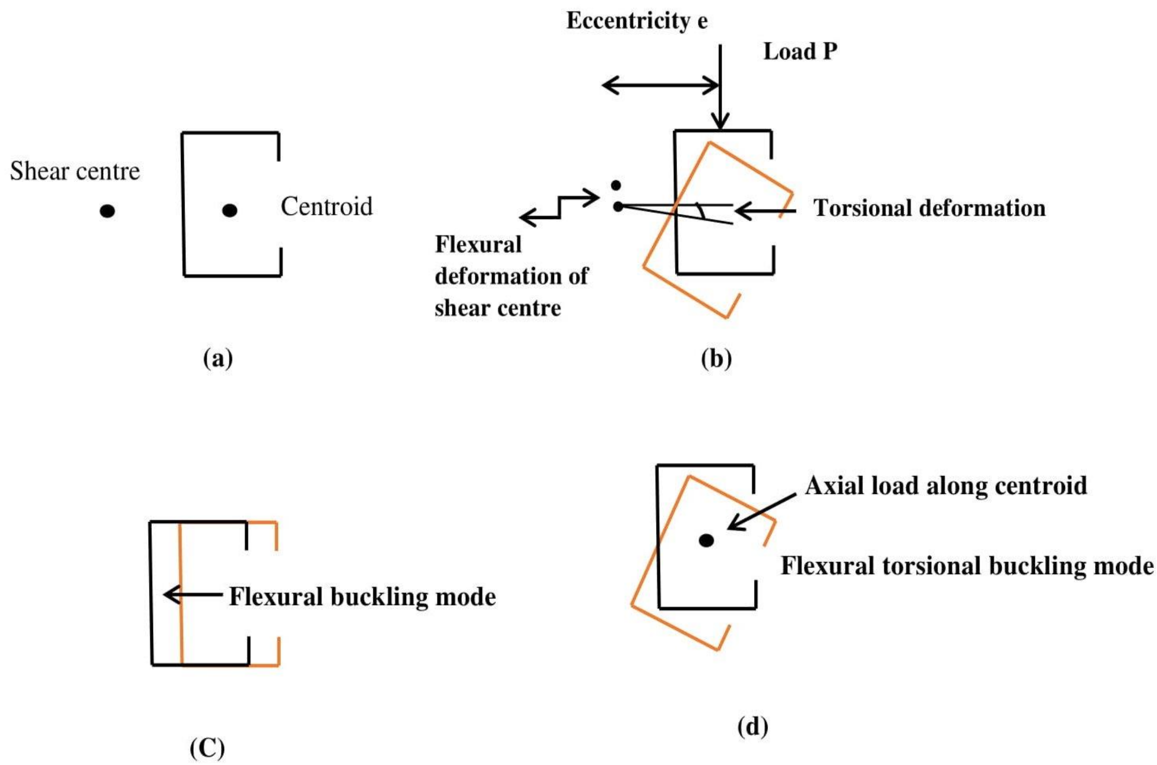

Figure 3. Typical torsional rigidity.

6. 3. Web Crippling, Bending Strength and Deflection

Web crippling is an important failure criterion for cold formed steel members. On the basis of many reaches, the North American specification provides guidelines to avoid web crippling. Web crippling can happen due to many reasons. No application of load bearing and end bearing stiffeners, very small thickness of the web, the inclination of web etc. are the most common reasons behind the web crippling of cold formed steel members. Bending strength and deflection are very important design criteria for especially flexural members. These members must have enough bending strength to deal with flexural effects. The deflection of these flexural members also must not exceed a certain limit under service loads. The North American specification edition 2007 provides two processes to calculate the strength of flexural members. One is based on "initiation of yielding" and other "inelastic reserve capacity". Sometimes members are subjected to simultaneous shear and bending such as cantilever beam or at interior support of a beam. In these cases, the webs of beam need extra consideration against buckling because the web can buckle at lower stress due to combined bending and shear. In members like column and beams, in case of compression stiffener is incorporated to increase the load-carrying capacity and improved the buckling condition.

7. CONNECTIONS

The connection is a very important part of structure, especially for steel structure. There are different methods used to connect one element to another in case of cold formed steel structure.

As the properties and geometry of cold formed steel sections are different to hot rolled steel section. The connection requirement of cold formed steel is also different. The design guidelines for cold-formed steel connections are developed to avoid connection failure. The major type of fasteners used to connect cold formed steel element can be classified as mechanical fasteners, welding, and adhesive bonding [10]. Also, purlins are used to connect the cold formed steel element by the sleeve and overlapped joint. At apex region gusset plate connection is common. Extra care should be taken for connection system as there are several reasons for connection to be failed. Bolts, the web of column and beam, gusset plate can fail if design and construction are not done properly.

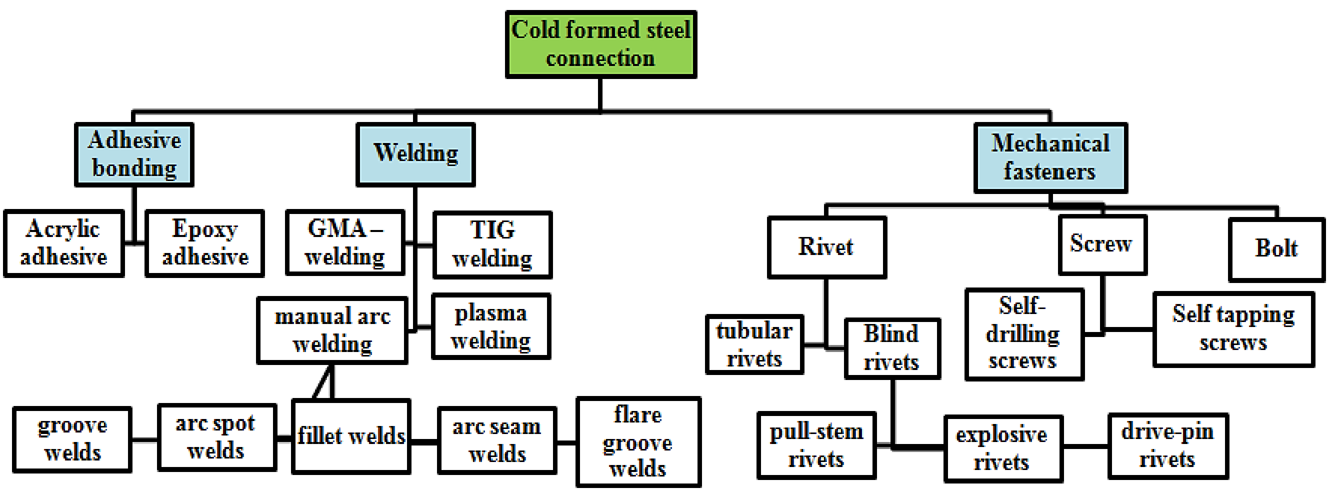

Figure 4. Cold formed steel connection

7. 1. Mechanical Fasteners

Bolts with nuts are one of the popular mechanical fasteners which connect elements through pre-drilled holes. The usual diameter of bolt used for thin-walled sections are M5-M16. The Bearing of nearest material of bolt, tearing of sheet, shearing of bolts etc. are the most failure observed in the cold-formed steel bolted connections. In case of a bolted connection, excess rotation of bolt can cause tearing of sheet material. In this situation, the use of screw to connect the roofing sheet type material to cold formed members is considered to be very effective [11]. Screws are also applicable for cold formed steel framing systems like roof trusses and others. Self-tapping and self-drilling screws are generally used in cold formed connection. Rivets are another type of mechanical fastener used in cold formed connection for making the connection simple and economical. Two major types of rivets used in cold formed steel connections are Blind rivets and tubular rivets. Pull-stem rivets, explosive rivets, drive-pin rivets are commonly used blind rivets. Tubular rivets are often used to fasten sheet metal.

7. 2. Welding and Adhesive Bonding

Welding is an important method to connect Cold-formed elements. GMA (gas metal arc) welding, manual arc welding, TIG (tungsten-inert gas) welding, plasma welding are common methods to join cold formed elements.

Groove welds, arc spot welds (puddle welds), arc seam welds, fillet welds, flare groove welds are the common types of welding methods generally used in cold-formed steel connection [12]. Adhesives are used in cold formed connection along with fastener to bring a good bonding. Bonded connections distribute the loads uniformly. Epoxy adhesive and acrylic adhesive are commonly used for cold formed steel connections. Acrylic adhesive is more flexible than the epoxy types.

8. PROTECTION AGAINST CORROSION

Durability is one of the most important factors for any type of structure. Cold formed steel members, sheets and fasteners can be subjected to an aggressive environment. Different types of coatings are used to protect cold formed steel element from deterioration. Detail of application of different procedure that should be applied to cold formed steel elements is explained in AISI “Durability of Cold-Formed Steel Framing Members” (2004). Galvanizing is considered to be the most popular protection method for its economy and effectiveness. Cold formed members that are directly in contact with concrete or exposed to the outdoor aggressive environment needs to be protected from corrosion, especially in case of rainwater and wet debris during the construction period industrial and marine condition. The corrosion rate of zinc is proved to be very low. Hot dip galvanized coating is popular for its long-term corrosion protection and economy. Hot dip galvanized coatings can be specified according to ASTM A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel hardware [13]. Hot dip galvanized coating is a thicker coating that produces a very effective barrier and also used in protection of cold formed fasteners. Due to the relatively small size of fasteners and threads, hot dip galvanizing of fasteners is not very common. In case of Fasteners, electroplated coatings, zinc coatings are used whose are generally thinner compared to the coatings applied to cold formed members. This corrosion protection layer also works as lubricate in case of the drilling process of fasteners. Fasteners that are subjected to higher aggressive environment need advanced protection. Higher corrosion protection can be achieved by metallic coatings, polymer coatings or two layer coating such as organic or inorganic coating over metallic coatings. Stainless Steel is also a very good solution for corrosion but due to less strength and higher cost, its use becomes limited.

9. PROTECTION AGAINST FIRE

Several fire accidents in buildings all over the world have made fire resistance of structural members very important properties. An increasing temperature during fire brings about changes in properties of cold formed steel elements and their strength as well as stiffness is greatly reduced. The researchers have become very attentive to the fire resistance performance of cold formed steel structures. Many important research works and experiment results make the basement of the design of cold formed steel against fire. Generally, cold formed section having a higher surface area and less volume such as thin-walled section is more susceptible to fire.

9. 1. Fire Protection of Cold Formed Steel Columns

The most important various failure criteria that are considered for column are generally yielding and different types of buckling. But when subjected to fire these properties are affected by elevated temperature. The axial load carrying capacity is proved to be affected by elevated temperature and becomes less [14].

To protect columns from this situation different methods are applied. Spray as fire protection is very common in the United States. It can reach all surfaces of sections having irregular shapes. The cost of spray protection also doesn't increase in terms of increasing depth as the material cost is less. The majority of the spray protection cost is involved with labor and equipment. Spray protection is not that popular in the United Kingdom. A fire protection Sprays limits the aesthetic properties of the structure. Also, over spray may sometimes cause economical issues. Building Design uses Cold Formed Steel Sections: Fire Protection (1993), refers limiting temperature for cold formed steel members based on their type and load ratio for three categories as A, B and C.

Table 1. Limiting temperature

Category	Application	Limiting temperature
A	Beams supporting concrete slab	550 ºC
B	Beams supporting timber floors	500 ºC
B	Stocky columns (e.g. in walls)	500 ºC
C	Slender columns (e.g. unrestrains)	450 ºC

The guideline for the application of board and spray protection is based on properties of cold formed element name as section factor. Section factor is the ratio of the perimeter that is subjected to heat and the cross-section of the element. As the thickness of cold formed steel section is smaller than hot rolled section, its section factor is very high compared to hot rolled section and is more susceptible to fire. Cold Formed Steel Sections: Fire Protection (1993), provides the thickness of both spray and board protection for different structural cold formed steel members.

9. 2. Fire Protection of Cold Formed Steel Beams

Cold formed steel beams has the advantages of having a higher strength to weight ratio. It has also the disadvantages of vulnerability to buckling, torsion, flexural rigidity. So these properties under fire are experimented by many researchers. In case of fire, the CFS beam behavior based on many excellent types of researches were reviewed by Laím et al. [15]. Plasterboards are commonly used to protect the cold formed steel beams. Cheng et al. [16]

showed the numerical result of buckling characteristics of cold formed steel beams with plaster board fire protection subjected to fire and carrying uniformly distributed load.

9. 3. Protection to walls and floor

Stud Walls and floors are commonly protected from fire by gypsum plasterboard. The gypsum plasterboard is applied to walls and floor as the internal finish. It can also be applied to the support of battens or auxiliary members. To protect this gypsum plaster boards additive and glass fiber is generally used to prevent breaking of the board and excessive rotation at connections. Floor elements generally need closely fitting material like tongued and grooved chipboard to enhance the proper insulation for the floors in case of fire. Sometimes wool insulation may also apply.

10. ADVANTAGES AND DISADVANTAGES

Like other construction materials of cold formed steel section has both advantages and disadvantages. The advantages and disadvantages of cold formed steel structures are shown in Table 2.

Table 2. Advantages and disadvantages of cold formed steel structures

Advantages	Disadvantages
The construction process is speedy because of using prefabricated element in the structure. It also reduces the waste of material in times of construction and also improves the quality of the work as site work is reduced.	Price is one of the greatest concerns in case of cold formed steel structure. Cold rolled steel costs twice as much as hot rolled steel.
High strength-to-weight ratio is one of the most advantageous properties of steel. The light weight of steel makes the foundation simple and also makes handling of element easier.	Buckling is one of the main problems in the cold formed steel element. Local buckling, global buckling, distortional buckling and shear local buckling are commonly seen in cold-formed sections.
Good quality of works and maintenance can be achieved. Cold formed steel structures also provide easy modification as non load carrying components. Termite-proof ness and rot-proof ness make cold formed steel section durable. Long-term corrosion resistance can be achieved by galvanizing cold-formed steel products.	Web Crippling is a great problem for cold formed steel sections. Web crippling can happen where concentrated load exists in support. Sometimes stiffener cannot be provided in cold formed sections and this problem becomes prominent.
Cold formed steel can be used in providing long span for its high strength to	Cold formed steel section has some limitation regarding ductility and plastic design. Sectional buckling and the effect of

weight ratio and larger open spaces can be available.	cold forming by the strain hardening reduces the ductility and restrict the option of plastic design. Therefore due to low ductility, cold-formed steel sections don't dissipate energy in the seismic resistant structures. But it can be applied to such structures for its high strength to weight ratio, but only the elastic design is allowed.
Steel is considered to be the most recycled construction material in North America having at least 25% recycled content. Steel products can be recycled and reused and thus reduce the use of other material like trees to save the environment. Thus the use of Cold-formed steel sections in building as primary structural members in building construction is growing.	Connections methods create problems in cold formed steel structure. Due to the very small thickness, conventional bolting and welding connection system are not appropriate all-time. Blind rivets, self-drilling and tapping screws, fired pins, recent technologies like press-joining, clinching and rosette system are applied to the cold-formed steel structures. Therefore the connection design is more complex and challenging to the engineers.
Dimensional stability is a great advantage of cold formed steel section. It does not expand or shrink with moisture content.	Fire small section factor of cold formed steel sections makes it more fire susceptible**.**
Cold formed steel construction generally needs no form work.	Corrosion for corrosion resistance board, spray and other protection are applied to cold formed steel which can increase the cost and affect the architectural view.

11. RESEARCH AND ACCOMPLISHMENTS

To solve the problems of cold formed steel section and to improve the whole structural system different research work are being carried out regarding codes and standards arena, Building Performance, durability, fire resistance, Construction Safety, framing method etc. Direct Strength Method (DSM) is one of the recent findings in designing cold formed steel section which is adopted in North American cold-Formed Steel Specification as an alternative method to the traditional effective width design approach. Seismic characteristics of cold formed steel structure are one of the important field of research nowadays. Lateral Design consideration for seismic effect on cold formed steel structure is incorporated in North American Standard for by the AISI Committee on Framing Standards (COFS). The AISI Committee on Specifications (COS) published design specification on Special Bolted Moment Frames cold formed steel structure. The effect of wind in cold formed steel structure is also a very important field of research. AISI, MCA and Factory Mutual Global (FM Global) sponsor Advanced experiments on this field like wind tunnel tests and electromagnetic uplift simulations etc. Studies on how the building performance can be improved by incorporating cold formed steel elements are also being done [17-18]. The performance of cold formed steel as metal roofing is found to be very advantageous for its energy efficiency, light weight, recyclability, durability. The performance of cold formed steel to enhance the durability of the structure has been investigated by different research programs. National Association of Home Builders (NAHB) investigated the viability of steel framing system subjected to various climatic condition for five years. The research findings clearly indicate better performance of cold formed steel regarding durability. The behavior of cold formed steel structures, when subjected to fire, is being investigated by various studies. Studies are being also done in safe and easy construction process of cold formed steel structure. To improve the material properties, architectural properties and other properties of cold formed. Advance technology for easy and fast cold formed steel production such as computerized design tools are also an interesting field of research.

12. CONCLUSIONS

The advantageous properties of cold formed steel for structural application are growing its popularity rapidly all over the world. But along with these advantages, there are some properties which affect the structural performance of cold formed steel. The smaller thickness of sections, forming process and complex structural behavior make challenges for structural engineers to ensure proper design and construction of cold formed steel structure. This study has reviewed the history, material properties, codes and specifications available, structural design consideration, corrosion and fire protection and research developments of cold formed steel structures. Advanced Researches on cold formed steel is being encouraged to overcome the challenging situation, improve its performance and modify the codes and guideline. These studies are making the engineer and architects confident to use the cold formed steel to improve the performance of a building.

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