A study on cold formed steel angle sections under Tension loading condition

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***Abstract*- In steel construction cold–formed structural members are becoming more popular and have a growing importance. Cold-formed steel exhibits a versatile nature which allows for the forming of almost any section geometry. Cold–formed steel sections are usually thinner than hot–rolled sections and can be subject to different modes of failure and deformation and therefore extensive testing is required to provide a guideline for the design of cold–formed thin–walled structural members.**

I. INTRODUCTION

The main mechanical properties (yield point, tensile strength and ductility) of cold–formed steel sections, particularly at the corners, are considerably different from those of the flat steel sheet, plate, strip or bar before forming. This is because the cold–forming operation increases the yield point and tensile strength, and at the same time decreases the ductility. Design codes have been generated in different. Countries amongst many others for cold-formed steel structures subjected to various loading scenarios which can cause buckling, bending and web crippling or a combination.

The design of industrial building is governed mainly by functional requirements and the need for economy of construction. Gradually, as industrial processes progressed, various steel products became available of rolled members and cold-formed elements. The metallurgical process of Hot rolling, used mainly to produce sheet metal or simple cross sections from billets describes the method of when industrial metal is passed or deformed between a set of work rolls and the temperature of the metal is generally above its recrytallization temperature.

Cold Rolled Steel rolling processes at temperatures that are close to normal room temperature are used to create cold rolled steel. This increases the strength of the finished product through the use of strain hardening by as much as 20 percent.

Although cold-formed steel is used for several products in building construction, framing products are different in that they are typically used for wall studs, floor joists, rafters, and truss members. Examples of cold-formed steel that would not be considered framing includes metal roofing, roof and floor deck, composite deck, metal siding, and purlins and girts on metal buildings.

Light-gauge cold-formed steel roof purlins were first introduced to the UK construction industry in the fifties, to replace heavier hot-rolled steel angle and channel sections. The purlin transfers load from the roof cladding to the primary steel rafters. Cold-formed steel roof purlins are used on a wide range of building types including retail and leisure, industrial, warehouses and distribution, healthcare and education.

A definition for cold-formed steel members, as given by both the AISI and AISC design specifications: "Shapes manufactured by press-braking blanks sheared from sheets, cut lengths of coils or plates, or by roll forming cold- or hot-rolled coils or sheets; both forming operations being performed at ambient room temperature, that is, without manifest addition of heat such as would be required from hot forming."

Fig 1 Cold formed sheet

A purlin is a secondary structural member that spans between the primary/main steel frame to support the roof cladding Cold-formed steel structural elements are widely used as structural elements in roofs, decks, wall panels, trailer bodies, agricultural equipments, aircrafts, etc. Angles are the most basic and widely used sections among the vari¬ous forms of all rolled steel sections available. Practically angles are connected with gusset plates through one leg and due to this there will be non-uniform stress distri¬bution due to eccentrically applied load. The reduction in load carrying capacity occurs due to a phenomenon as shear lag effect.

In building construction, cold-formed steel products can be classified into three categories: members, panels, and prefabricated assemblies. Typical cold-formed steel members such as studs, track, purlins, girts and angles are mainly used for carrying loads while panels and decks constitute useful surfaces such as floors, roofs and walls, in addition to resisting in-plane and out-of-plane sur- face loads. Prefabricated cold-formed steel assemblies include roof trusses, panelized walls or floors, and other prefabricated struc- tural assemblies.

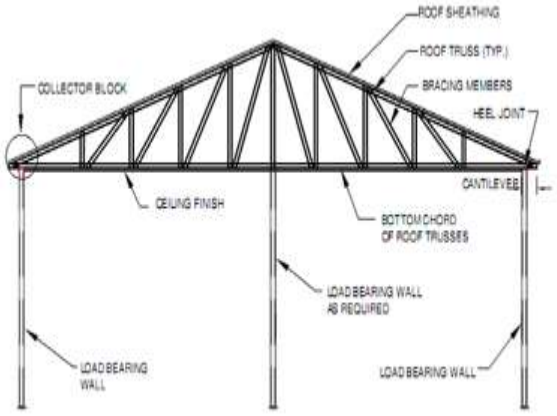

Fig 2 CFS Roof System

Thin sheet steel products are extensively used in building industry, and range from purlins to roof sheeting and floor decking. Generally these are available for use as basic building elements for assembly at site or as prefabricated frames or panels. These thin steel sections are cold-formed, i.e. their manufacturing process involves forming steel sections in a cold state (i.e. without application of heat) from steel sheets of uniform thickness. These are given the generic title Cold Formed Steel Sections

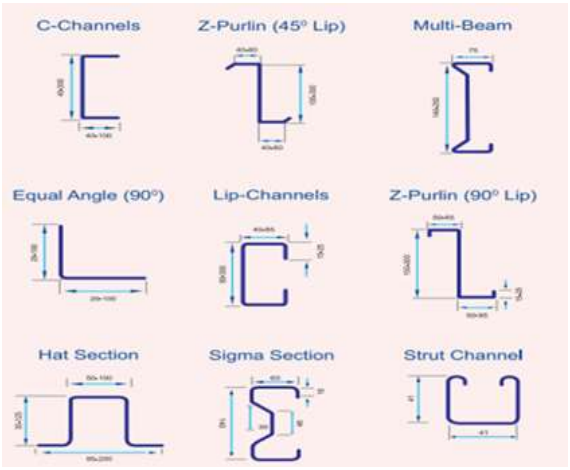

Fig 3 cold formed steel sections

Sometimes they are also called Light Gauge Steel Sections or Cold Rolled Steel Sections. The thickness of steel sheet used in cold formed construction is usually 1 to 3 mm Much thicker material up to 8 mm can be formed if pre-galvanised material is not required for the particular application. The method of manufacturing is important as it differentiates these products from hot rolled steel sections. Normally, the yield strength of steel sheets used in cold-formed sections is at least 280 N/mm2, although there is a trend to use steels of higher strengths, and sometimes as low as 230 N/mm2.

II. ECONOMY OF COLD FORMED STEEL

Light steel framing using the cold-formed Steel (CFS) sections is one of the Industrialized Building System that highly recommended into our construction industry. Industrial Building System is not just speed up the construction time and reducing material usage, but also guaranteed the quality of the building, e.g., in acoustic and heat performance. The use of CFS as light steel framing system has not been popular as a preferred option in construction practice in Indonesia and Malaysia. Therefore, there is a need to investigate the economic aspects of the CFS as light steel framing system in our local industry, conduct comprehensive testing and parametric studies to create the guidance and procedures of the analysis and design of such building.

This information on the concept, design and construction methods are to be introduced to our local designers and builders. Most structural

engineers are familiar with the application of cold formed steel sections in purlins and side-rails, which are highly engineered products for specific applications. However, the cold-formed steel is proposed to be designed as Angle sectiona as that the economic aspects can be highlighted. It was found that the use of cold-formed steel as Angle section could increase the strength .It is hoped that the use of CFS as composite beam should be able to offers the following benefits, speed of construction on-site, less disruption due to construction operations, high degree of quality control in factory production, economy of scale through repetitive production, off-site installation of services and complex equipment and cost effective.

Cold-formed steel structural members can lead to more economic design than hot-rolled members as a result of their high strength to weight ratio, ease of fabrication and construction. Further, their increased yield strength, their post-buckling strength and their suitability for a wide range of applications are the key advantages of cold-formed sections. These sections are essentially thin-walled members with moderate to very high flat width to thickness ratio of the web or flange plate components. Such members are susceptible to local buckling at relatively low compressive, shear, bending or bearing stresses.

The use of cold-formed steel structures has become increasingly popular in different fields of building construction. These sections offer very flexible design using different cross-sectional shapes but can put more demands on the designer because elastic local and global buckling phenomena need to be taken into account practically in all designs.

III. BEHAVIOR OF COLD FORMED STEEL

The resulting stress distribution justified the blockshear strength equation by use of area along the grossshear plane. The von Mises stresses indicate that block shear failure might occur in a two bolt connection, andnet section failure might occur in three and four bolts connection. The factor of safety for angles under tension in the limit state format giving due considerations to block shear failure and yielding of gross section was obtained. The knowledge and understanding of the behavior ofcold-formed steel bolted connections to determine tensile apacity, bearing capacity and the interaction of tension and bearing capacities were performed. Besides building industry, they are employed in motor vehicles, railways, aircrafts, ships, agricultural machinery, electrical equipment, storage racks, house hold appliances and so on. In recent years, with the evolution of attractive coatings and the distinctive profiles that can be manufactured, cold formed steel construction has been used for highly pleasing designs in practically every sector of building construction. In this chapter, the background theory governing the design of cold formed steel elements is presented in a summary form.

IV USES OF COLD FORMED STEEL

Steel has the highest strength-- to-- weight ratio of any building material. Moreover, the strength of cold-formed steel also provides architects with greater flexibility, allowing designs that incorporate longer spans and other architectural features. Durability. Steel is inorganic, and thus impervious to termites, rot and mold. A protective layer of zinc and other metallic coating steel provides long-term durability that research demonstrates can last hundreds of years without any deterioration. Stability.

Due to its consistent chemistry, steel behaves in a highly predicable manner when subjected to the structural loads and stresses imposed by high wind and seismic forces. Because steel cannot absorb moisture, its use also eliminates most of the expansion and contraction of construction materials that produces cracks, warps, and other defects in both internal and external finishes. Non-combustibility. Steel does not burn and will not contribute to the spread or intensity of a fire. Because of this, cold-formed steel projects can easily be designed to meet code fire rating requirements. Non-combustible structures, like those built with cold-formed steel framing, have a better loss history than combustible wood framing. This often translates into lower costs and broader coverage for many types of construction insurance. Read more in this white paper. Sustainability.

Steel is the only building material that is infinitely recyclable. As a recognized green building material, cold-formed steel framing projects can earn credits for green building ratings such as LEED and similar programs. Cost-effectiveness. Cold-formed steel offers cost savings on a number of fronts. By helping

to minimize fi re risk, the use of cold-formed steel results in lower insurance costs for builders and owners. Additionally, panelized cold-formed steel construction methods produce shorter construction cycles, allowing builders to complete steel-framed projects months faster than with other framing materials. Finally, framing with cold-formed steel generates far less material waste than traditional wood framing

V. ADVANTAGES OF COLD FORMED STEEL

- Cold forming has the effect of increasing the yield strength of steel, the increase being the consequence of cold working well into the strain-hardening range. These increases are predominant in zones where the metal is bent by folding.
- The effect of cold working is thus to enhance the mean yield stress by 15% - 30%. For purposes of design, the yield stress may be regarded as having been enhanced by a minimum of 15%.
- Cross sectional shapes are formed to close tolerances and these can be consistently repeated for as long as required.
- Cold rolling can be employed to produce almost any desired shape to any desired length.
- Pre-galvanised or pre-coated metals can be formed, so that high resistance to corrosion, besides an attractive surface finish, can be achieved.
- All conventional jointing methods, (i.e. riveting, bolting, welding and adhesives) can be employed.
- High strength to weight ratio is achieved in cold-rolled products.
- They are usually light making it easy to transport and erect.

VI. PROPERTIES COLD FORMED STEEL

- Lightweight - Cold-formed steel components weigh ap-proximately 35% to 50% less than their wood counterparts, which means that they are easy to handle during construction-tion and transportation.
- High-strength and stiffness – As a result of the cold-forming process, cold-formed steel possesses one of the highest strength-to-weight ratios of any building material. This high strength and stiffness result in more design options, wider spans and better material usage.
- Fast and easy erection and installation – Building components made of cold-formed steel can be fabricated with high ac-curacy in a plant and then assembled on job sites, which greatly increases erection efficiency and ensures construc-tion quality.Dimensionally stable material - Cold-formed steel does not expand or contract with moisture content. In addition, it does not split or warp as time goes by. Therefore, it is di-mensionally stable. Cracked gypsum sheathed walls, nail head popping and other common problems with wood- framed structures can be virtually eliminated in buildings with cold-formed steel stud walls.No formwork needed – The use of cold-formed steel decks eliminates the formwork for pouring concrete floor. In ad-dition, composite action between the steel deck and con-crete increases floor strength and stiffness.

Durable material - Cold-formed steel is durable because it is resistant to termites and rotting. In addition, galvanized cold-formed steel products provide long-term resistance to corrosion.Recyclable nature - Steel is North America's No. 1 recycled construction material, with a minimum 25% recycled con-tent.

Steel products used in construction are infinitely re-cyclable, with no degradation in structural properties. It can be recycled and reused. Steel-framed housing dramati-cally reduces the amount of trees consumed for residential construction, thus conserving one of nature's most pre-cious resources.

VII CONCLUSION

- Cold-formed steel (CFS) cross-sections can be optimized to increase their load carrying capacity, leading to more efficient and economical structural systems.
- In recent years, the demand for high strength materials for wide range of structural applications has been instrumental for more

developments in cold-formed steel sections as compared to the hot rolled steel sections.

- Therefore, the understanding of cold formed steel performance becomes an important issue to be studied.
- This research provides a detailed investigation of the structural behavior on single and double angles when subjected to eccentric tension load. The non-uniform stress distribution across the cross-section of the angle is important in deciding the load carrying capacity of the specimen.

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