Devolopment of temporary joining elements in lightweight metal systems between complexity of form and simplicity of installation (Analytical study)

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Summary

Complexity and simplicity are two interrelated terms that refer to each other in many fields of knowledge. Complexity is an integrative structural arrangement that indicates the number of possibilities in a system. In design, complexity is a case that stems from dimensions and philosophical visions of different design trends. Complexity is usually employed to change the stereotypes of systems and products to interest the end user. Simplicity means that something is easy to understand or do and it is a way of describing seemingly complex results using just a few rules, bits, and interactions. The structural assembly of metall systems includes many single elements that are grouped temporarily together, each of them has a secondary function that shares together to achieve the overall function of the required system. The multiplicity of parts and components of the system may result in varying degrees of structural and functional complexity, the degree of which varies according to the function of the system, its environment and the characteristics of its components. As long as the end user becomes a part of the system building process, it is important that complexity is not reflected in the end user and the process of assembling system is simplified with the least amount of skill.

When developing metall systems, many designers often focus on one of two aspects: either the orientation towards the complexity of the structural forms of the system through the complexity of the parts that it consists of, or the orientation towards simplifying the assempling process in order to reduce the manufacturing cost and facilitate maintenance operations. Hence, the **problem of research** included the following questions: From where does the process of developing light metal systems begin: from the inside or from the outside? How can enhance the structural solutions that based on a single system designing to meet different functions? How can the complexity of the form be combined with the simplicity of construction to enhance the economic, formal, aesthetic and functional values of these systems? How can metal systems be developed and made extremely diverse in formality, structural complexity and structural simplification?

Then the **Research aims** make an analytical study about development of temporary joining elements in lightweight metal systems, between complexity of form and simplicity of installation. This aim was achieved on the basis of a research hypothesis according to: the balanced mege between the complexity of the form and the simplicity of assempling in the elements of the assembly construction of metall systems, which will lead to the enrichment of the functions and competitive valeuss of those systems. It makes its structural and functional

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images more effective in meeting changing user requirements, achieving ease of assembly, use and maintenance, and creating forms of seemingly complex metal systems, but they are easily constructed from simple parts. The aim was accomplished according to an **analytical descriptive approach** based on three **topics**: First, joining in prefabricated metal systems, second, the simplicity and complexity in designing prefabricated metal systems, third, an analytical study about devolopment of the components of the synthesized construction between simplicity and complexity.

Keywords:
(Lightweight metal systems, Simplicity, Complexity, Prefabrication, temporary joining and Separated jointing nodes)

A. First: Temporary Joining in Prefabricated Metal Systems ... Terms and Classifications

This topic included following sub-titles

1. Prefabrication as a concept, objectives, advantages and its relationship to mineral systems
2. Standardization: as a concept and its importance for mineral systems
3. Degrees of freedom: as a definition, patterns and importance for mineral systems for mineral systems**.**
4. Classifications of temporary connection elements in metallic systems.. Opinions and limitations

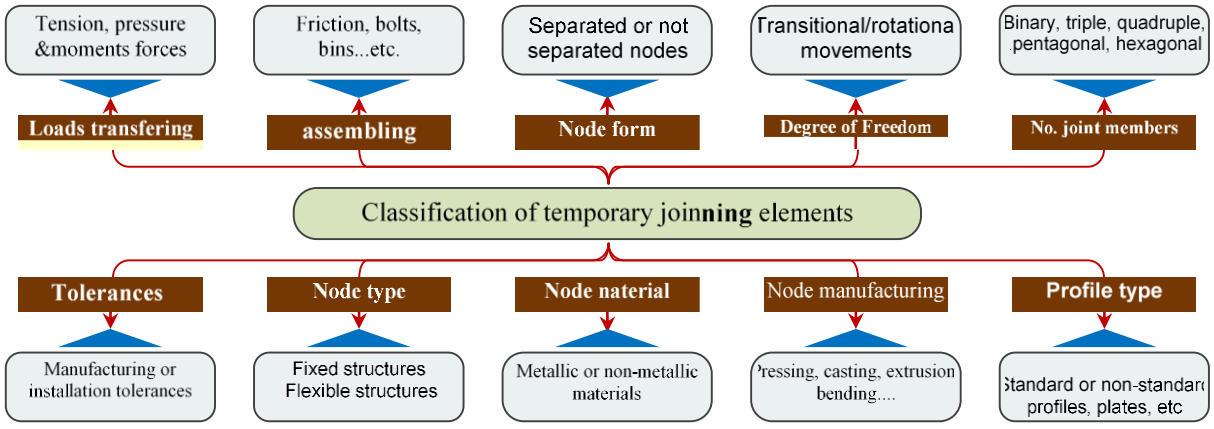

Figure (1) Determinants of classification of temporary joinning elements that used in prefabricated metal systems (prepared by researchers)

B. Second: Simplicity and complexity in designing and instalation of prefabricated metal systems.

This topic included following sub-titles

1. Simplicity and complexity.. Concepts and opinions
2. Simplicity and complexity in design and instalation process

C. Third: Development temporary joining elements between simplicity and complexity... an analytical study

This topic included following sub-titles

1. Considerations that affect the design of the assembly building elements
2. Components of assemblies for prefabricated metal systems
3. Design for temporary assembly and simple construction.. Considerations and levels
4. Where does the development of metallic systems start...from the inside or from the outside**?**
5. The development of basic alternatives to the components of the assembly construction of metallic systems... an analytical study

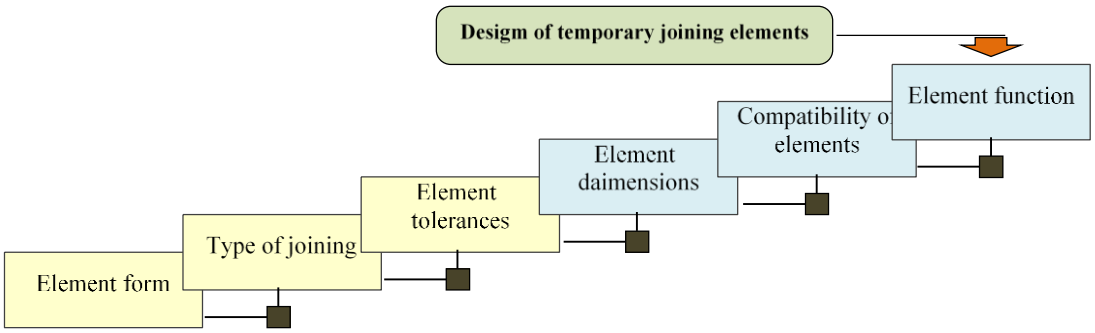

Figure (2) Important considerations in designing the elements of the assembly of metal systems (prepared by researchers)

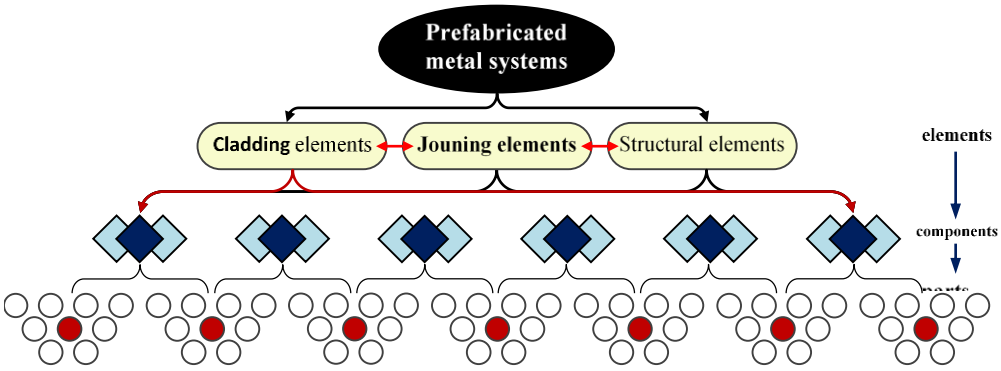

Figure (3) Prefabricated metal systems as structural parts, components and elements (prepared by researchers)

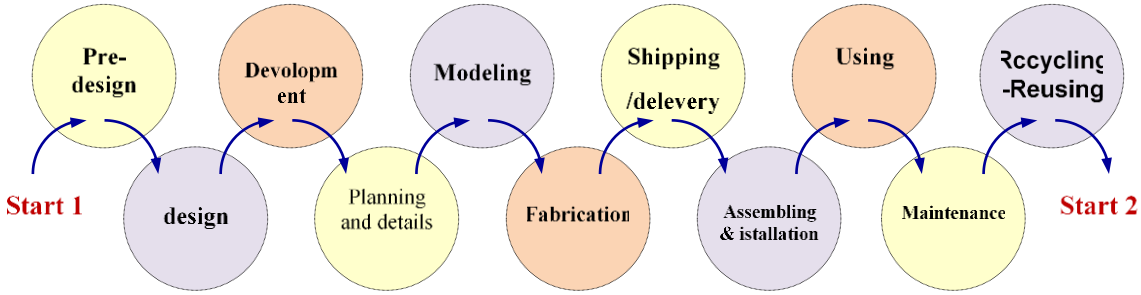

Figure (4) basic levels in the life cycle of prefabricated metal systems (prepared by researchers)

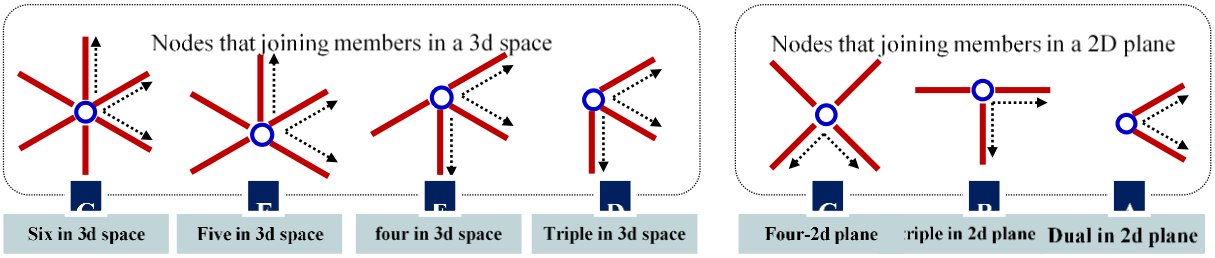

Figure (6) The seven possible alternatives to junction nodes in metal furnishing systems designed according to orthogonal geometric networks (prepared by researchers)

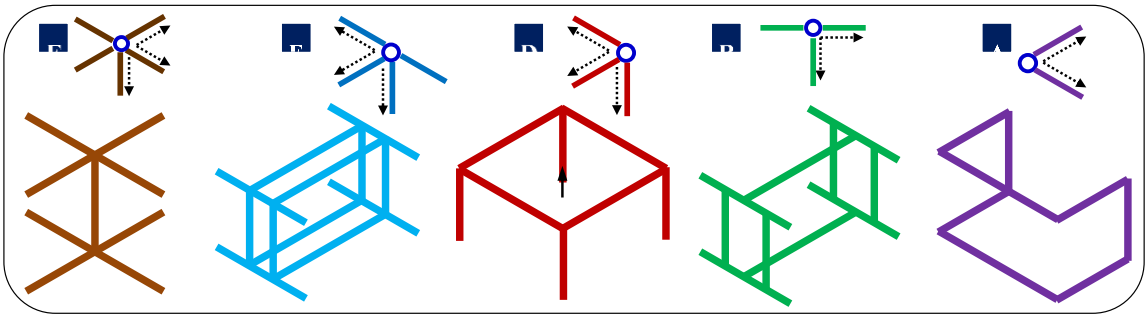

Figure (9) Suggested structural formations for metal systems that are assembled with only one of the seven alternatives to the junction nodes (prepared by researchers)

D. Discussion and conclusion

Metal furnishing and construction systems are three-dimensional configurations, manufactured by prefabricated methods, characterized by functional and structural diversity, and their structures consist of standard or constructed sections, and their parts are precisely assembled in node or non-node connections, and are located in simple or compound formations .For this reason, there was a need to employ the elements of the aggregate construction in those systems, which allows achieving the principle of unity and consistency within a framework in which all the details of the target system are subject to a single approach .The use of assembled building elements allows achieving structural complexity and deviating from the traditional patterns of metal systems, and makes the user a participant in the formation and construction.

The effectiveness of design solutions for the components of the assembly building has a crucial role in determining the final cost of the system, and identifying the techniques required to prepare and simplify the assembly processes for its components and achieve structural efficiency and its competitive value .A thorough study of the elements and knots of the joint requires an understanding of how the forces flow in the joint members, the structural formation of the members, the mechanism by which they are fixed in the knot, the shape of the knot and its components, the methods of manufacturing it, the materials that can be made from it, the related tolerances, and the degrees of freedom that can enhance the flexibility of the system as a whole .The design effectiveness of the temporary assembly of metal systems is based on studying all considerations at each level to meet the requirements of the user, and to ensure that the assembly and construction sequence is simplified and performed with the least amount of costs and skills .This requires attention to structural sequence maps, dimensional compatibility between components, understanding the nature of materials and

connection details, accurate employment of manufacturing methods, taking into account the disassembly and installation methods for the user, and meeting quality and safety standards Enhancing this efficiency requires the designer to constantly search for alternatives related to the possibility of integrating parts of the system with others or removing them completely, or changing the positions of some parts, or thinking about changing the material to obtain higher specifications, or accommodating more parts in flexible assembly nodes .Metal systems are developed and made more flexible with the possibility of providing forms characterized by physical diversity and structural complexity that go on two parallel lines: the integration of the seven jointing alternatives in the least possible number of joint nodes, while enhancing the degrees of freedom for some elements of the assembly building, whether on transitional or rotational levels .The disintegration of metal systems into parts and components that can be produced, transported and assembled, will increase the structural link between these components, and this will reflect positively on the simplification of manufacturing, transportation and assembly processes and enhance their competitiveness.

E. Results

The research concluded with a discussion and conclusion of relevant results.

1. Prefabrication is an integrated approach to the preparation of system components in a controlled area and then delivered and assembled later at the site of use, and it gives system reliability, achieves higher quality and workmanship, reduces environmental impacts, allows working in safe environments, and facilitates reuse or recycling of system components.
2. Profiling is a unified system that ensures the symmetry and homogeneity of parts and components of the system, which allows it to be possible to repeat the preparation of the same parts with the same specifications and standards, and reduces costs and limits multiplicity and allows the possibility of replacing identical parts and facilitates assembly operations by the knowledge of the non-technical person.
3. Degrees of freedom are one of the means of achieving flexibility in metall systems, It is related to the movement of its components in three-dimensional spaces to perform transitional or rotational movements and it requires determining the number of inputs that must be provided in the components of the system in order to create predictable outputs.
4. Simplicity in metal systems is to meet user requirements while reducing excessive variety of shapes and components, enhancing stability and compatibility between them, and simplifying and organizing construction and maintenance processes.
5. Complexity in metal systems is an audit of the design data through the abundance of details, the diversity of treatments, and the intensification of structural elements; in addition to that it enhances their formal, functional and aesthetic values and carries more visual focus.
6. The elements of temporary joining are critical points that require care in their design to ensure the organization, simplification and standardization of the assembly processes of the components of the system and the promotion of functional and aesthetic values that are compatible with the economics and efficiency of construction.
7. The elements of temporary joining are limited to metal systems formed according to orthogonal geometric grids, in seven basic alternatives distributed on two- or three-dimensional levels, and a connecting node may be designed for each alternative or design flexible nodes that can achieve all or some of the seven assembly alternatives.

8. The discrepancy in the alternatives of the seven connecting elements in the existing metal systems is due to a difference in their structural treatments such as (the flexibility of the joint, its material and method of manufacture, the section of the connecting members, the installation method, the tolerances, the simplicity of installation, the degrees of freedom**.**

9. The future development of prefabricated metal systems aims to expand the studies related to them in two parallel lines: the first is to enhance their capabilities, functions and economies, and the second is to delve into the study of the form, performance and functions of their components and to provide solutions and structural alternatives that are diverse in shape, size and space**.**

10. The effectiveness of the design for temporary assembly and simple construction of metal systems is based on two principles: the first is to reduce the number of assembly operations at the end-use site, and the second is to reduce the diversity of the assembly building elements that make up the system**.**

11. The processes of developing prefabricated metal systems start from the inside and then gradually grow outward to reach a suitable form or shapes that fulfill the required function, focusing on the internal details and making them more flexible to reach potential alternatives characterized by flexibility and structural diversity**.**

12. Diversity in the parts and components of the system may result in varying degrees of structural and functional complexity, the degree of which varies according to the function and environment of the system, and because the end user has become a participant in building the system, it is important to take into account the simplification of the process of assembling and creating the system**.**

13. Mixing between structural complexity and structural simplicity aims to enhance the innovative formal values of the target system with innovative treatments and new formats that the user participates in formulating**.**

14. The process of developing the assembly building elements includes several points, such as devising a design solution for each of the seven alternatives of the target system, or devising a solution for one alternative based on the network planning of the members of the system, or creating a single link that is flexible and can achieve all or some of the connection alternatives. The seven or degrees of freedom are integrated into some elements of the assembly building, whether on transitional or rotational levels to achieve more flexibility**.**

15. Recommendation: The development of metal systems requires conducting more studies on enhancing the durability, lightness and agility of the joint members and nodes, supporting functional and structural flexibility, enhancing structural economy and simplicity in assembly and maintenance, employing modern technologies, developing materials with less environmental impacts, creating effective and accurate coupling solutions With the exploitation of degrees of freedom, employ the principles of profiling and scaling.

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