Universitatea Politehnica Timişoara
Facultatea de Construcţii
Departamentul de Construcţii Metalice şi Mecanica Construcţiilor

COMPOSITE STEEL-CONCRETE STRUCTURES

- CURS 5-b-

Composite Connections

Conf.dr.ing Adrian CIUTINA

Notele de curs pot fi descărcate de pe pagina de web
http://www.ct.upt.ro/users/AdrianCiutina/

CHAPTER IV – COMPOSITE CONNECTIONS
§ 4.1 Introduction

- A **composite connection** may be defined as a joint between members where one or more of the members is a composite section (usually the beam) and the reinforcement connecting the members is intended to contribute to the resistance, stiffness and ductility of the joint.
- The connections in a variety of different forms of construction can be considered and designed as composite connections. These include the beam-to-column connections in a steel frame where the columns are non-composite (bare steel, 'I', 'H' or box section) and the beams are designed to act compositely with the floor slab. In this type of structure the floor slab may consist of any of the following forms of floor construction:
  - concrete acting compositely with a profiled metal decking
  - an in-situ flat slab
  - a flat slab constructed from pre-cast concrete units.

§ 4.1 Introduction

- Other forms of composite connection exist and include slimfloor connections, connections between composite beams and composite columns and between composite beams.
- Most design procedures for composite connections assume that the forces are carried by a combination of the bare steel connection and the reinforcement.
- Such an approach assumes that the **reinforcement is properly designed and detailed** to transfer the forces from one member to another. Where the reinforcement is not continuous or where only a brittle welded mesh is provided the capacity should be based only on the behaviour of the bare steel connection.
- The method given in Eurocodes 3 and 4 includes a system for classifying connections based on their moment resistance and rotational stiffness. This approach makes the difference between pinned, semi-rigid and rigid connections.

§ 4.2 Types of Composite Connections

- Figure below shows a typical composite connection, which consists of a steel joint and a concrete slab with continuous tension reinforcement across the joint. In this joint the reinforcing bars and the upper part of the steel connection provide the tensile resistance and, provided there is no axial force in the beam, these forces are balanced by compression forces between the lower part of the beam's steel section and the column.

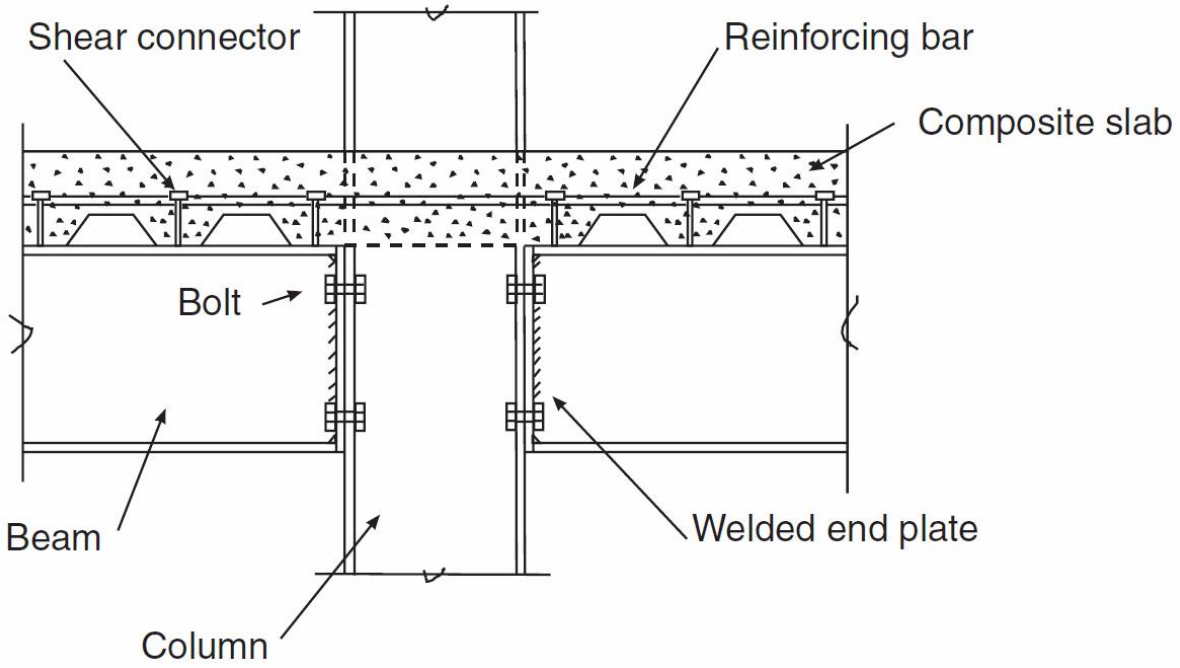


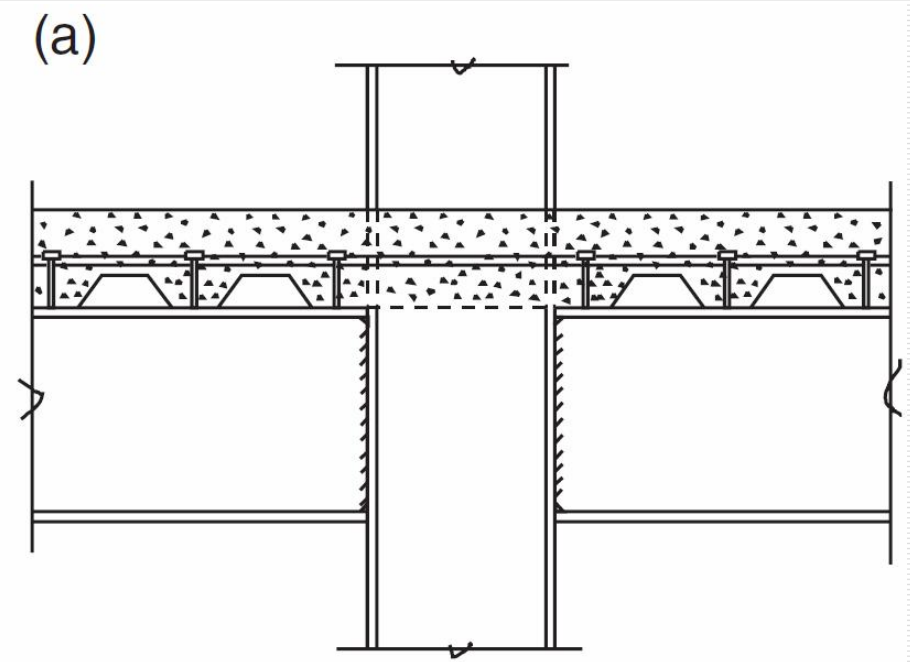
Figure: Typical composite connection

§ 4.2 Types of Composite Connections

- In composite connections the vertical shear resistance of the slab is small and difficult to calculate. It is therefore assumed that the vertical shear resistance of the connection is provided by the steel connection alone.
- The type of steel connection used can have a significant influence on both the construction speed of the structure and the performance of the composite connection.
- While the choice of steel connection is usually based on simplicity, duplication and ease of fabrication, its influence on the behaviour of the composite connection must also be considered.
- A range of typical beam-to-column composite connections with different steel joints is shown in figures below.
- Similar configurations can be used for beam-to-beam joints.

§ 4.2 Types of Composite Connections

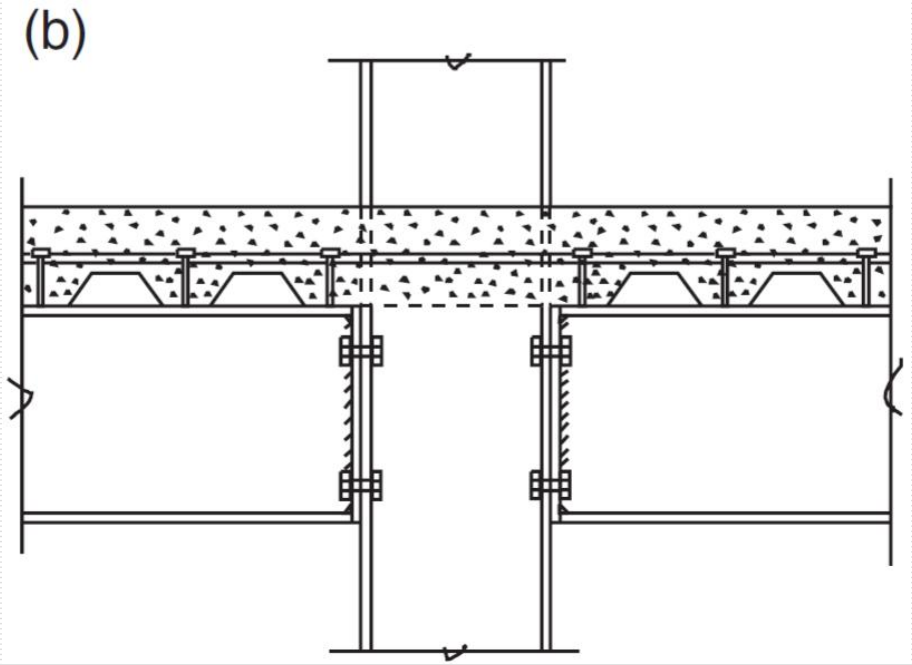
- Site welded connections, (see figure right), can be used as part of a composite connection. They provide a high degree of strength and stiffness.

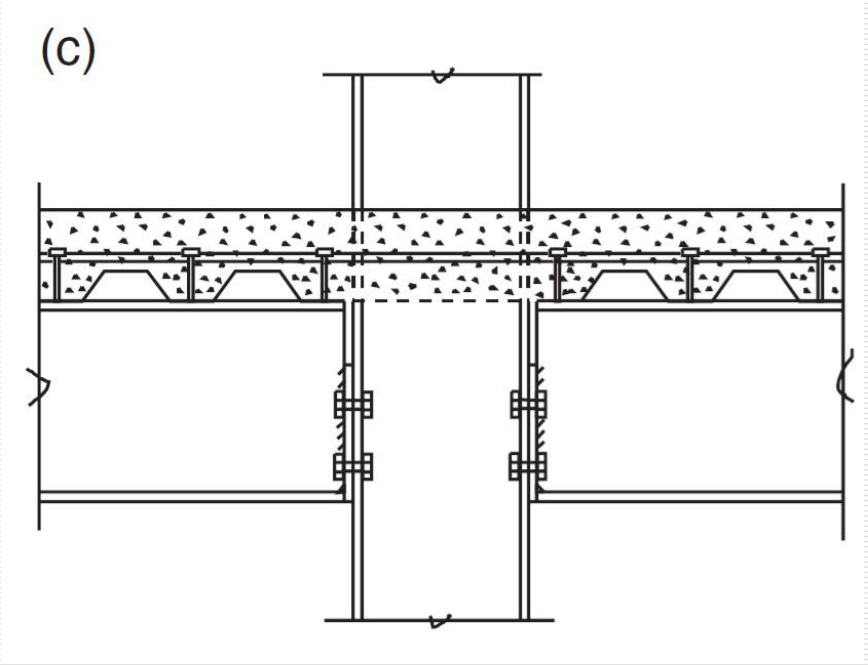


- However they are expensive to realise and their resistance may be limited by local instability of the compression flange or by excessive deformation caused by column flange bending if horizontal stiffeners are not provided.
- Furthermore, the welds must be designed using a high partial safety factor to prevent brittle failure.
- This type of connection is rarely used but with careful planning there is no reason why they should not be used.

§ 4.2 Types of Composite Connections

- ***End-plate connections*** like those shown in figure b and c are commonly used as part of a composite joint. These can be flush, extended or partial depth and consist of a single plate fillet welded to the end of the steel beam and site bolted to a supporting beam or column.
- This type of steel connection is relatively inexpensive but has the disadvantage that there is no room for site adjustment.



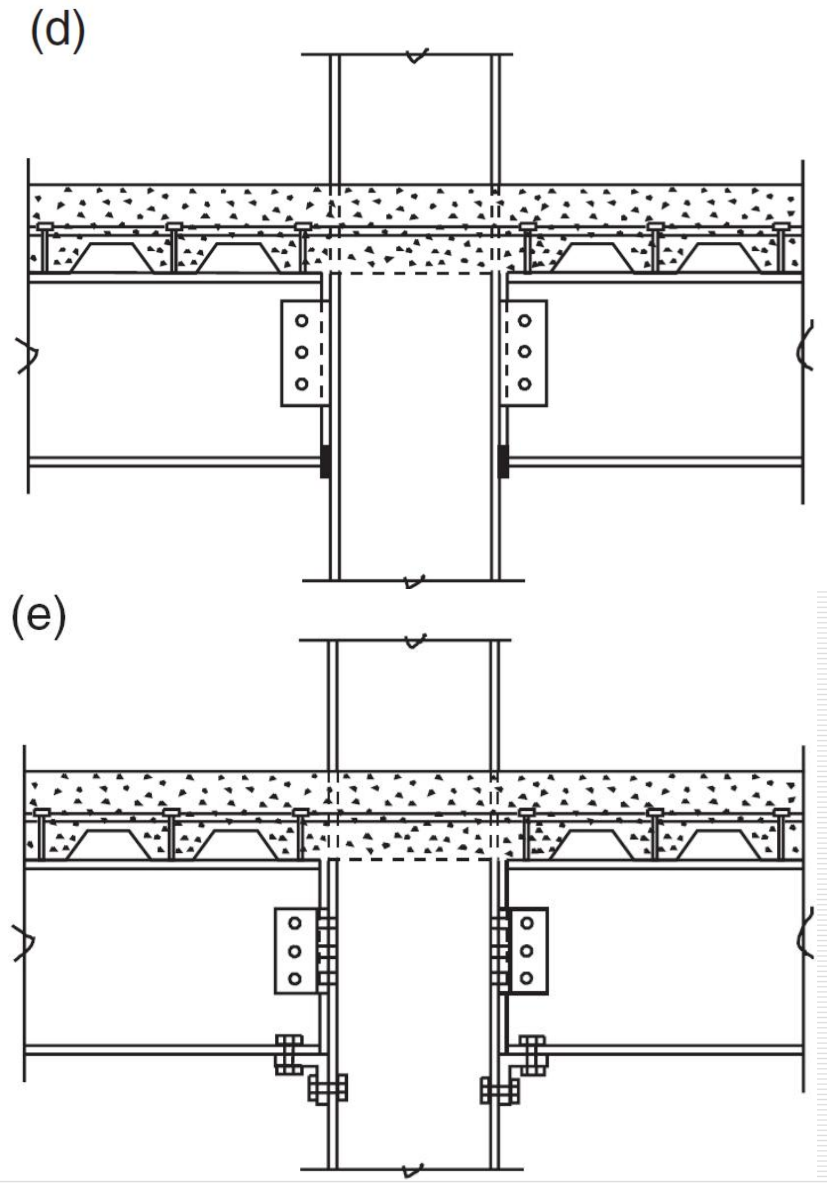


§ 4.2 Types of Composite Connections

- The contribution of the end plate to the overall behaviour of the composite joint will be influenced by the yielding of the column flange and/or end-plate and by local instability of the column web.
- Another advantage of using an end-plate is that the overall strength, stiffness and ductility of the composite connection can be adjusted by varying the arrangement and properties of the end-plate and its components.
- ***Fin plate connections*** are often used in practice because they are cheap to fabricate and simple to erect. However, fin plates do not provide the same degree of continuity as end-plate or welded connections.
- Furthermore, the fin plate must carry the compressive forces alone and this can result in lateral-torsional buckling and a reduction in both moment capacity and ductility.

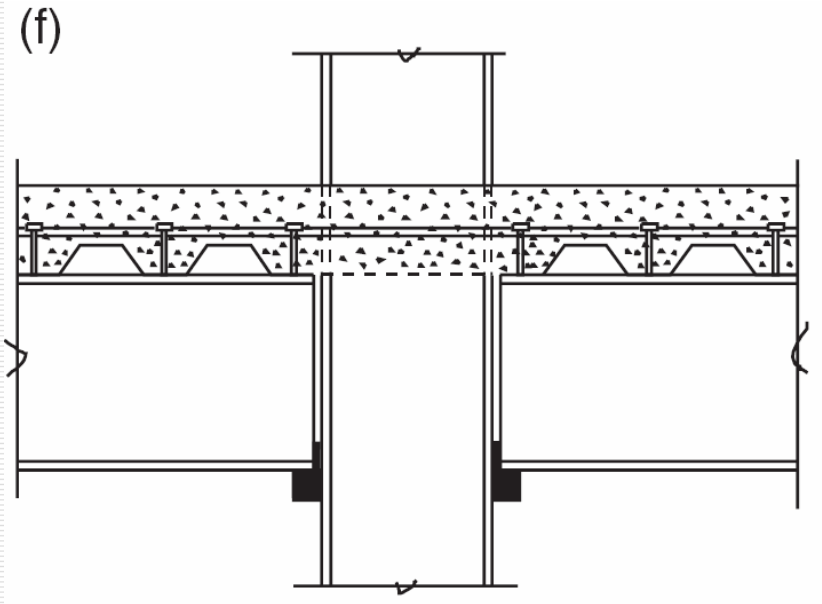
§ 4.2 Types of Composite Connections

- As an alternative, a contact plate (like the one shown in figure d) can be placed between the column flange and beam compression flange to enhance the compression capacity of the connection.
- ***Cleated connections*** like those shown in figure e can be used. In this connection the bottom flange cleat carries the compression. However, its effectiveness can be reduced by bolt slip caused by clearance holes. Tightening the bolts to increase the friction between the steel cleat and bottom flange of the beam can improve this phenomenon.



§ 4.2 Types of Composite Connections

- ***Contact plate connections*** or boltless connections like those shown in figure f are sometimes used Europe. By welding a plate to the column they ensure a direct transfer of the compression forces without slip, while the reinforcement transmits the tensile forces, assuring a certain moment transfer.



§ 4.3 Design Principles

- Eurocodes 3 and 4 give three approaches for the design of a structure in which the behaviour of the connection is fundamental. In the Eurocodes these methods are defined as **Simple Design**, **Continuous Design** and **Semi-Continuous Design**.
- Elastic, plastic and elastic–plastic methods of global analysis can be used with any of these three approaches.
- ***Simple design*** is based on the assumption that the beams are simply supported and implies that the connections must be sufficiently flexible to restrict the development of any bending moment.
- When using this approach the connections are classified as **nominally pinned** no matter what method of global analysis is used.
- If the ***continuous approach*** is adopted the type of connection used will depend on the method of global analysis. When elastic analysis is used the joints are classified according to their stiffness and **rigid connections** must be used. When plastic analysis is used the connections are classified according to their strength (moment capacity) and **full-strength connections** must be used.

§ 4.3 Design Principles

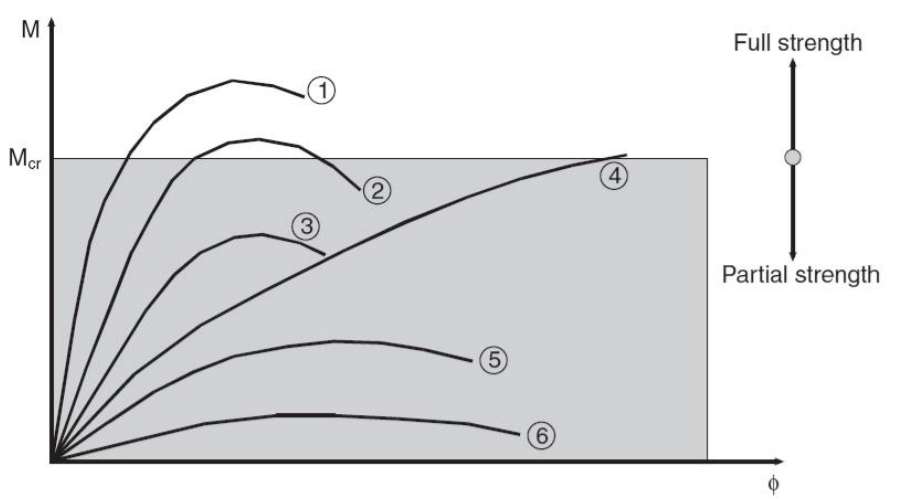
- The term full-strength relates the strength of the connection to that of the connected beam. If the moment capacity of the connection is higher than that of the connected beam then the connection is full-strength.
- If the elastic–plastic method of global analysis is used then the connections are classified according to both their stiffness and strength and rigid, full-strength connections must be used. These connections must be capable of carrying the design bending moment, shear force and axial load while maintaining the original angle between the connected members.
- The ***semi-continuous method*** accepts the fact that most practical connection are capable of providing some degree of stiffness and their moment capacity may be limited.
- When elastic analysis is used the connections are classified according to their stiffness and semi-rigid connections can be used.

§ 4.3 Design Principles

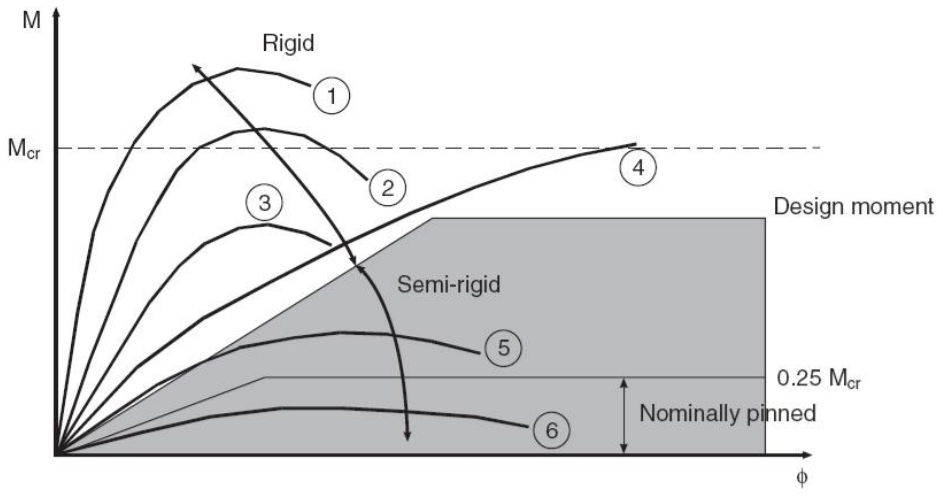
- If plastic global analysis is used the connections are classified according to their strength. Connections that have a lower moment capacity than the connected member are termed partial-strength.
- In this case the connection will fail before the connected member and must therefore possess sufficient ductility to allow plastic hinges to form in other parts of the structure.
- Where the elastic–plastic method of global analysis is used the connections are classified according to both their stiffness and strength and semi-rigid, partial strength connections are used.
- Figures below show the moment-rotation curves for a number of different types of composite connection.
  - It is clear that connections 1, 2 and 4 can be classified as full-strength because their moment capacity exceeds that of the connecting beam.
  - The moment capacity of connections 3 and 5 is lower than the connecting beam and these be classified as partial strength connections.

§ 4.3 Design Principles

- Finally, connection 6 is a nominally pinned connection.



Classification by strength



Classification by rigidity

- For a system that includes 'semi-continuous' connections it is preferable to use the structural properties of the connection as a way of classifying the joint.
- To do this, Eurocode 3 and Eurocode 4 comprise a classification system to define the boundaries between the three types of connection in the stiffness and strength domains.