

PRACTICAL DESIGN OF STEEL STRUCTURES



Karuna Moy Ghosh

Practical Design of Steel Structures

Based on Eurocode 3 (with case studies):
A multibay melting shop and finishing mill building

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Preface

There are numerous books available discussing the analysis and design of steel structures. These texts consider isolated parts of a structure, with the emphasis primarily on theory and little focus on practical design and the considerations and challenges that engineers face in the design office and on the construction site.

This book takes a holistic approach presenting a comprehensive description and explanation of the analysis and design process for any structure and its component structural elements, from the initial design concept through to final construction.

The text has been written with the structural calculations presented in a simple and lucid way. Taking a step-by-step approach, the book discusses design philosophy, functional aspects of structure, selection of construction material and accompanying methods of construction, with reference to the relevant clauses of codes of practice. Included are design sketches, tables and references.

For illustrative purposes, a specific structure (accompanied by detailed worked examples) has been selected and is outlined below:

A multibay melting shop and finish mill building—The multibay melting shop and finish mill building is a complex structure that houses several heavy duty overhead electric travelling cranes. These have high vertical dynamic impact (40%) and 10% horizontal transverse crane surge on the crane girders, subsequently transferring impact on the supporting members. The structural members have been analysed and designed to resist the above dynamic impact forces.

This book describes the practical aspects of analysis and design based on the latest steel structure design codes of practice **Eurocode 3**: Part 1-1 and Part 1-8: *Design of steel structures for buildings and Design of joints*. Included is the comparative analysis of results for model design of a beam and column applying Eurocode 3 and BS 5950, 2000. The following relevant Eurocodes applicable to the analysis have also been included: **Eurocode 0**: *Basis of structural design* (BS EN 1990:2002) and **Eurocode 1**: *Densities, self weights, imposed loads, snow loads, wind loads, and cranes and machinery*.

This book will be invaluable as a practical design guide and reference text book for final year university students, newly qualified university graduates, practising engineers, consulting engineers working in the design office and at the construction site, and for those appearing for professional examinations.

Author's Note

To facilitate ease of calculation and compliance with the code, equation numbers provided in the text are those used in the code.

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CHAPTER 1

General Principles and Practices

This book considers theory and its application in the context of the analysis and design of structures, addressing in particular the behaviour of the structural elements of a multibay steel-framed industrial building under the actions of heavy moving loads due to electric overhead travelling (EOT) cranes and wind forces. The analysis and design of the structural members are done in compliance with the Eurocodes, with case studies included.

Before discussing analysis and design, we must first plan the structural arrangement in relation to the requirements of the layout of machines and equipment. We must then consider the selection of construction materials, taking account of availability and cost within the scheduled construction programme and budget. We must also examine the buildability of the structure with regard to space restrictions, the method of construction, the location, ground conditions and seismic information about the site.

The above points will be discussed in detail in Section 1.2.

1.1 Brief description of the structure

1.1.1 Structural arrangement

The building complex comprises a multibay melting shop and finishing mill building. The melting shop consists of a melting bay, a hopper storage bay, an intermediate bay and a casting bay. The finishing shop consists of a rolling shop bay, a finishing mill bay and a motor and power room bay. The finishing shop is located adjacent to the melting shop, as shown in plan in Figs 1.1 and 1.2. The two buildings are separated by an expansion joint. The spacings of the stanchions in the melting bay, storage hopper bay, intermediate bay and casting bay are 28.5, 12, 27 and 30 m, respectively. In the finishing shop, all columns are spaced at 30 m centres. In the melting shop, the height of the building to the eaves level is 35.5 m except for the hopper bay, where the eaves level from the floor level is 45.5 m. In the finishing shop, the height of the building to the eaves level is 22.5 m from the ground floor. Both buildings house overhead electric cranes, as shown in section in Figs 1.3 and 1.4.

1.1.2 Overhead electric travelling cranes

Overhead electric cranes, of capacities ranging from 290 t (2900 kN) to 80 t (800 kN), run through the melting, intermediate and casting bays. The finishing shop carries cranes of capacities ranging from 80 t (800 kN) to 40 tons (400 kN). The storage hopper bay consists of hoppers storing heavy briquette iron, coke and limestone to supply to the melting furnace during operation (see Figs 1.3 and 1.4).

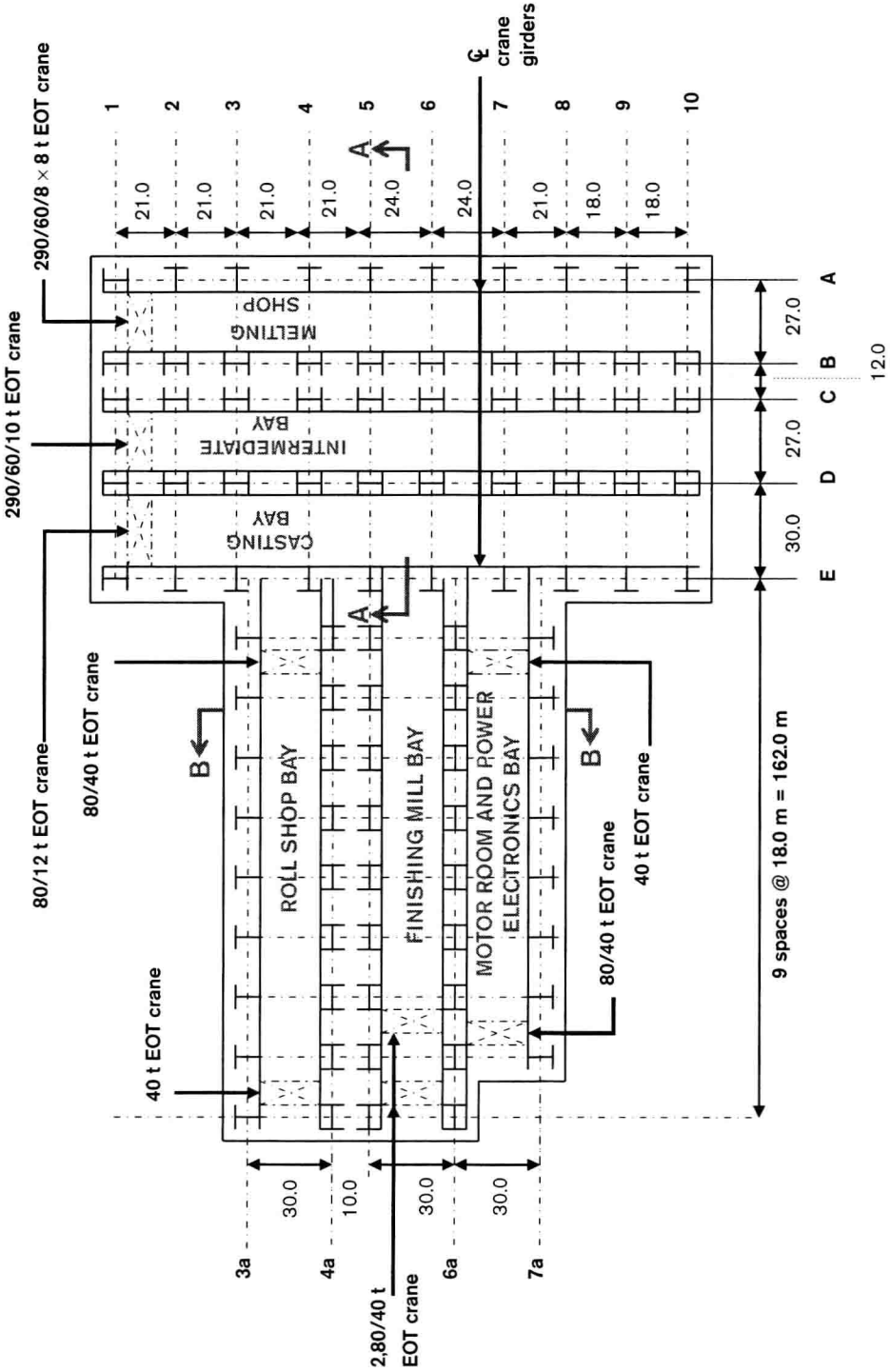


Fig. 1.1. Plan at crane girder level (showing layout of columns and cranes)

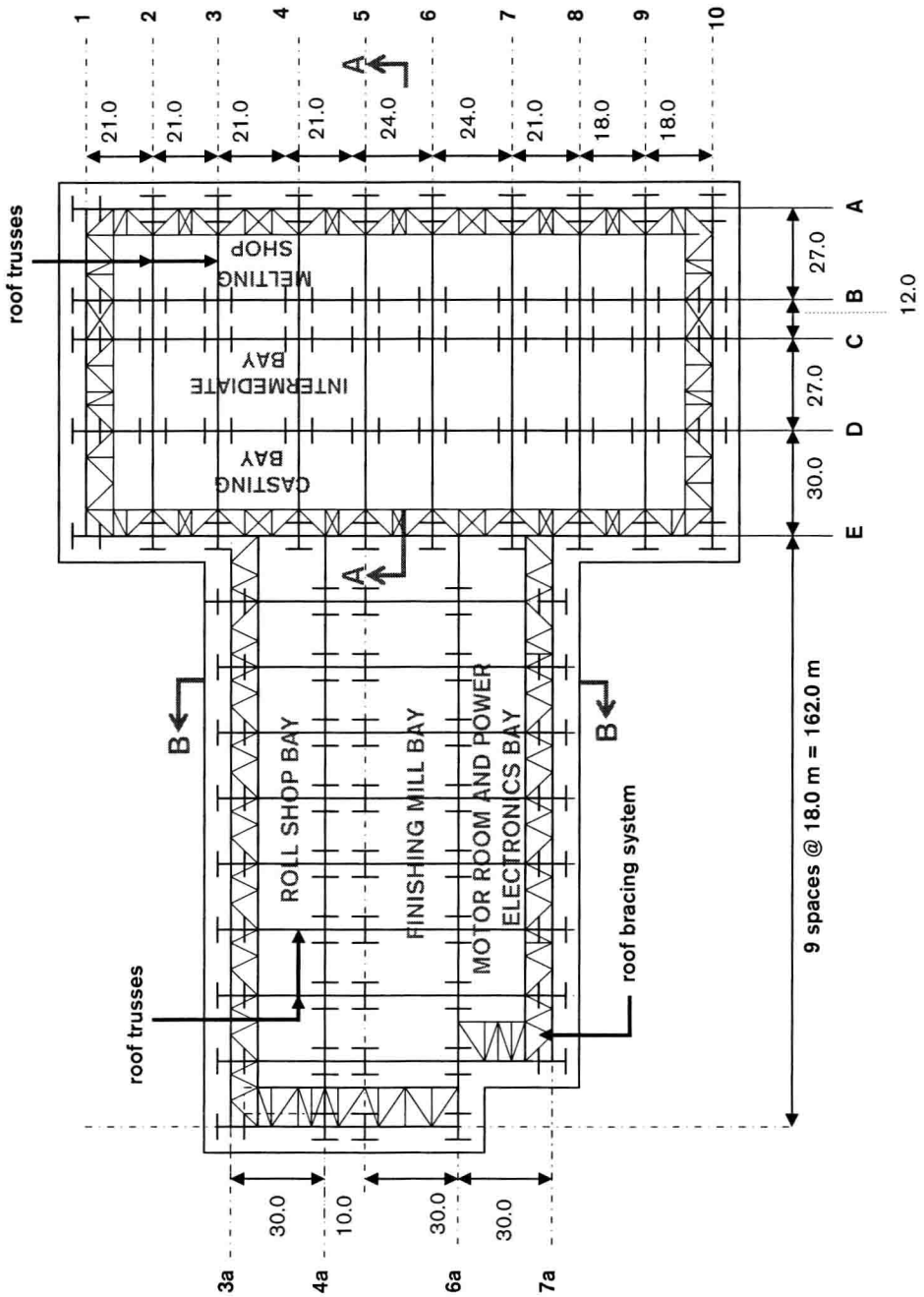


Fig. 1.2. Roof plan (showing roof trusses and horizontal bracings)

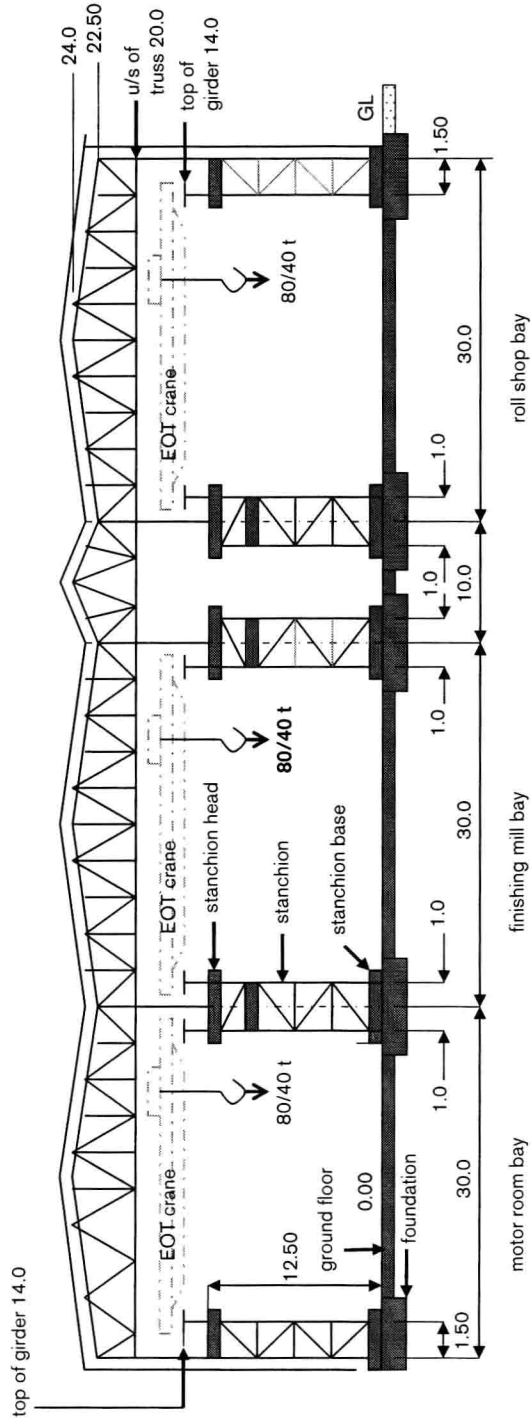


Fig. 1.4. Section B.B (see Figs 1.1 and 1.2), showing structural arrangement

1.1.3 Gantry girders

The top level of the gantry crane girders in the finishing shop is 14 m from the operating-floor level, and in the melting shop the top of the gantry crane girders is 25 m from ground level in the melting and intermediate bays and 24 m from ground level in the casting bay.

1.1.4 Fabrication of structural members

The crane girders in the melting and intermediate bays are of built-up welded-plate girder construction, and in the rest of the bays normal universal beams are used. The stanchions and roofs are of fabricated trussed-type construction and shop fabricated. Horizontal and vertical bracing systems are provided along the horizontal and vertical planes of the roof trusses and stanchions to resist wind and crane surges, respectively (see Fig. 1.5).

1.2 Design philosophy and practice

Before we proceed with the actual analysis and design of the structure, we need to consider the following aspects in order to reach a satisfactory solution to the problem:

- the functional aspects of the structure;
- alternative structural arrangements and choices of spacing of the columns and frames or trusses;
- the structural system and type;
- the buildability of the structure;
- the choice of an open or covered structure;
- the selection of the construction materials;
- the choice of shop or site connection of the component steel structures;
- the sequence and method of erection of the steel structures;
- the location, ground conditions and seismic information;
- the environmental impact of the structure;
- the design concept.

The above aspects must satisfy the requirements of Eurocode 3 and other relevant Eurocodes.

1.2.1 Functional aspects of the building

This building plays a vital role in the production of finished steel products. The melting and finishing shop, built adjacent to each other, form an important heavy industrial building complex with heavy cranes running throughout the building when it is operational. Within the building, a conveyor system supplies materials such as heavy briquette iron, coke and limestone. These materials are stored temporarily in bins hanging in the storage hopper bay. During operation, these raw materials are fed into the furnace through a conveyor system. The molten metal is then transferred to the casting bay by cranes. From here the product is transported to the finishing bay to be used in the production of continuous plate, which is rolled in the roller bay. The final product is transferred to the storage building.

The whole operation is automatically controlled from a control room adjacent to the finishing bay. Power is supplied from a generator situated in the motor and power house bay.

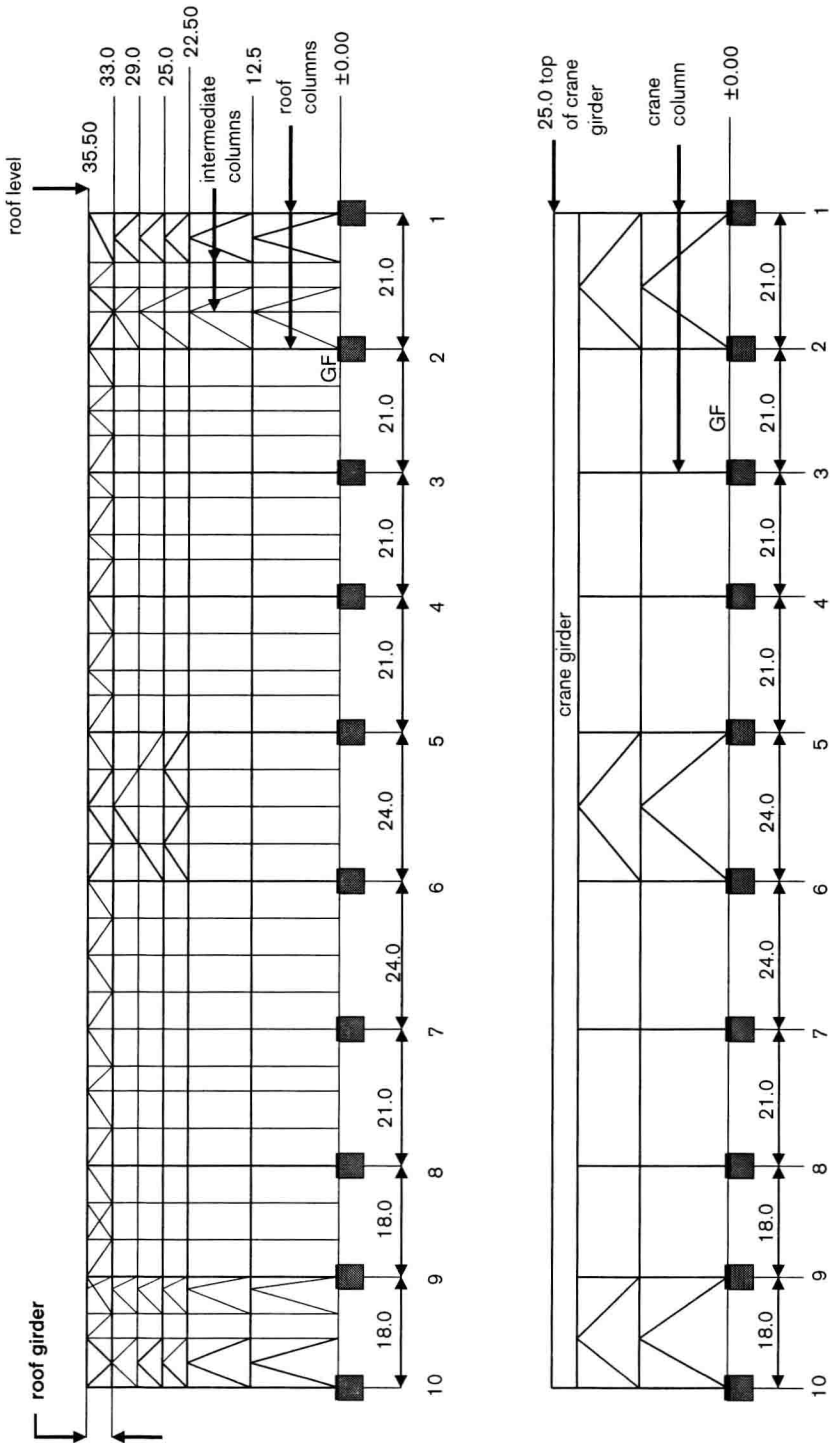


Fig. 1.5. (a) Wind bracing system along stanchion line A (see Figs 1.1 and 1.2). (b) Bracing system along stanchion line A for longitudinal active force from crane