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BUILDING ETHICAL ENGINEERS: INSIGHTS FROM A GUIDE TO INTEGRATING ETHICS IN CIVIL ENGINEERING EDUCATION

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ABSTRACT

Ethics education is crucial for civil engineers due to the far-reaching impact of their work. This article presents the Chapter on Civil Engineering that is part of the forthcoming "Routledge International Handbook of Engineering Ethics Education". In particular, it explores how ethical considerations should be integrated throughout civil

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engineering in a project's lifecycle, from design to decommissioning. Ethical considerations like professionalism, social responsibility, sustainability, and safety are addressed throughout. Each of these considerations is analysed across project phases, including planning, construction, operation, and decommissioning. Contents related to different civil engineering disciplines are examined (i.e., construction, energy, environment, water, transportation, urbanism). The chapter presented herein aims at fostering discussions around ethics in civil engineering classrooms, with a view of educating new generations of civil engineers that are strong not only technically, but holistically, thus ensuring that their projects prioritise safety, sustainability, and societal well-being.

1 INTRODUCTION

Unlike other engineering disciplines with a more recent origin, civil engineering has a long history dating back to ancient civilisations. From the Roman Empire's roads and viaducts to the achievements in Egypt, Greece, and China, civil engineering has demonstrably shaped societies and improved quality of life by providing essential infrastructure. This rich history is accompanied by the establishment of professional bodies like the American Society of Civil Engineers (ASCE) and the Institution of Civil Engineers (ICE) to ensure ethical practices that benefit society.

Ethics education is crucial for engineers, and it is increasingly being incorporated into engineering programs around the world. However, the importance that civil engineering has for society has not traditionally been reflected in the education of civil engineers. While civil engineers have the potential to solve pressing global challenges and enhance quality of life, undesired outcomes can arise if safety, sustainability, and public well-being are not prioritised. News headlines about infrastructure collapses and corruption cases highlight the importance of ethical considerations.

To avoid these adverse effects, future civil engineers must be equipped to understand and solve ethical dilemmas. Engineering ethics education is vital for this purpose. In addition to technical expertise, a well-rounded civil engineering education should include a comprehensive exploration of ethical questions, real-world case studies that showcase the ethical challenges faced by professionals, and opportunities for ethical decision-making and reflection.

Considering the above, this article presents the Chapter on Civil Engineering (Josa et al.) that is part of the forthcoming "Routledge International Handbook of Engineering Ethics Education" (Chance et al.). It aims to provide an overview of the ethical issues, dilemmas, and challenges that are included in the chapter, which addresses how these issues can be tackled by both students and practicing civil engineers.

2 CONTEXT: THE HANDBOOK

The Routledge International Handbook of Engineering Ethics Education (Chance et al.) is an open-source handbook on Engineering Ethics Education (EEE), which has been compiled by a diverse team of scholars. This handbook aims to be a comprehensive resource for both new and experienced researchers in the field.

The content of the book is organised into six main sections, each focusing on a different aspect of EEE. These sections cover the foundations of the field, explore contributions from other disciplines, delve into various teaching methods, and address the role of accreditation. Additionally, the handbook explores ethical issues specific to different engineering disciplines and provide guidance on assessing various aspects of EEE programs. Each section contains multiple chapters that review existing research and present the different perspectives and dilemmas surrounding each topic.

3 DETAILS OF THE CIVIL ENGINEERING CHAPTER

3.1 Development of the chapter

This chapter's development involved an iterative process through a series of meetings. The first meeting served as an initial discussion, laying the groundwork for the chapter's content and direction. Following this, a matrix was developed to structure the chapter (as will be further detailed later). The matrix then underwent refinement to ensure it effectively captured the intended content. Once finalised, the next phase involved filling the matrix with specific concepts and relevant case studies to illustrate the ethical considerations within the chosen framework.

The review process of the chapter involved discussions with the teams writing the chapters on other engineering disciplines, as well as three rounds of reviews by authors of other chapters and the handbook editors.

3.2 Contents of the chapter

Figure 1 shows how the chapter is organised. The structure of the chapter emphasises that ethical thinking should be integrated from the very beginning of a project and continue through to its completion.

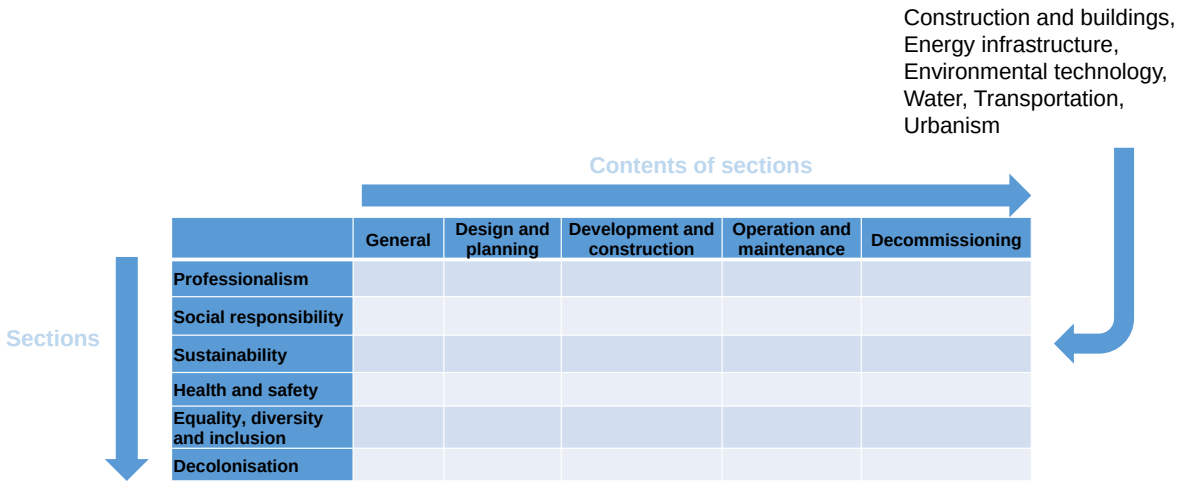

Fig. 1. Structure of the chapter

The chapter focuses on six main areas: construction and buildings, energy infrastructure, environmental technology, water, transportation, and urbanism. Each section is further divided into subsections that explore different stages of a project's life cycle, from general planning and design to construction, operation, and eventual decommissioning.

Then, running alongside the project phases are additional considerations that highlight the importance of ethics throughout the entire process. These ethical considerations include professionalism, social responsibility, sustainability, health and safety, as well as equality, diversity, inclusion, and decolonisation.

There is a part of the Handbook dedicated to methods through which these contents can be integrated into the curricula (e.g., case studies, problem-based learning). In the chapter presented herein, examples of potential case studies are included, together with questions that can be used in class to guide discussions. The titles of the case studies included are: the National Society of Professional Engineers Board of Ethical Review Case 97-13, Saadiyat Island Abu Dhabi and Worker Rights, Powerhouse Kjørbo, La Scala Opera House Asbestos Deaths, Trans-inclusive sanitation, and The Central Corridor, Tanzania.

In what follows, the main contents included for each of the ethical considerations (organised in sections) are presented.

3.2.1 Professionalism

This section discusses the ethical expectations of engineers throughout a project's journey. It starts with foundational concepts, exploring professionalism and its significance in construction. Also, the section delves into established codes of conduct, outlining the principles that guide ethical practice.

As a civil engineering project progresses, the focus shifts to ethical considerations within specific phases. During design and planning, the section discusses maintaining design integrity, avoiding conflicts of interest, and considering the long-term social and environmental impact of projects. A particularly challenging scenario, clashes of obligations, is also addressed here. This involves situations where client confidentiality clashes with public safety, and the section provides questions to critically think about navigating these conflicts while prioritising ethical duties.

The section then continues to the construction phase, emphasising ethical considerations like quality control, adherence to safety regulations, and responsible material sourcing. It also tackles the sensitive issue of corruption and bribery within the industry, offering strategies for identifying and avoiding such practices.

Finally, the section explores the ethical responsibility of whistleblowing. This involves those cases where engineers witness unethical or potentially harmful practices.

3.2.2 Social responsibility

This section dives into the ethical obligations engineers have towards society and the far-reaching consequences of their work. In particular, it opens with a discussion on the concept of social responsibility in engineering drawing on Chance et al. (2021), moving beyond technical considerations to explore the impact projects have on communities and the environment.

The section discusses the ethical principles guiding this responsibility, such as fairness, justice, and the well-being of future generations. It then tackles the distribution of responsibility, identifying who bears the ethical burden for different project aspects. This could involve engineers, contractors, clients, and governments.

The concept of Corporate Social Responsibility (CSR) is explored, examining how engineering firms can integrate social responsibility into their practices. Strategies for

minimising negative project impacts and maximising positive contributions are discussed.

Moving into specific project phases, the section focuses on ethical considerations during design and planning. This involves considering the needs of vulnerable communities, minimising environmental disruption, and ensuring equitable access to the project's benefits. Recognising the potential downsides of new technologies, the chapter explores how to identify and mitigate unintended consequences during design. It emphasises the importance of considering the long-term social and ethical implications of innovation.

Regarding ethical considerations during construction, fair labour practices, responsible sourcing of materials, and minimising the project's impact on local communities are addressed. Highlighting the ethical complexities of global supply chains, the section dives into responsible sourcing practices and avoids human rights abuses or environmental exploitation within these chains. A real-world case study, the Saadiyat Island Abu Dhabi and Worker Rights (Human Rights Watch, 2009), is used to illustrate the challenges of social responsibility in construction projects.

Regarding operation and maintenance, this involves ensuring proper infrastructure upkeep to prevent disasters, such as bridge inspections or ensuring proper dam maintenance. The section also delves into the ethical complexities of who bears responsibility when a project fails. Additionally, effective communication with stakeholders throughout the project's life cycle is crucial for social responsibility.

Finally, ethical considerations for decommissioning involve responsible dismantling of structures, recycling or repurposing materials, and minimising the environmental impact of the decommissioning process.

3.2.3 Sustainability

This section dives deep into the environmental impact of engineering projects and how to minimise it throughout the entire process. This section explores the challenges of climate change and the ethical obligation to future generations (intergenerational justice). The section introduces frameworks like the Sustainable Development Goals (SDGs) and the capabilities approach to guide sustainable practices. It also touches on the concept of "Net Zero" emissions.

For design and planning, the focus is on incorporating sustainability principles from the very beginning (Engineering Council, 2021). This involves using design criteria that prioritise energy-efficient buildings, sustainable materials selection, and minimising resource consumption. The section also explores the concept of a circular economy, where materials are reused or recycled, and discuss potential criticisms of this approach.

Ethical sourcing of materials takes centre stage during the development and construction. The section discusses strategies for identifying and using materials with minimal environmental impact, including recycled content or those produced through responsible practices (Cole & Fedoruk, 2015).

As for operation and maintenance, the focus shifts to sustainable operation of the completed project. This involves strategies for maximising energy efficiency throughout the life of the building or infrastructure. A real-world example, the

Powerhouse Kjørbo, a highly energy-efficient office building in Denmark, is used to illustrate these concepts (UNFCCC, n.d.).

The end of a project's life also has sustainability implications. The last part of this section explores the challenges of obsolescence and waste generation during decommissioning. Strategies for minimising waste and promoting repurposing or recycling materials during demolition are discussed (Lawlor, 2015).

3.2.4 Health and safety

The "Health and Safety" section prioritises the well-being of everyone involved in a project, from conception to completion. The section emphasises the importance of identifying and mitigating potential hazards throughout a project's lifecycle.

For design and planning, the focus is on integrating safety considerations from the earliest stages. This involves discussions around incorporating safety features during design, evaluating cheaper versus safer alternatives, and prioritising long-term safety over short-term cost savings (Toole, 2007).

The development and construction section prioritises the safety of workers on the construction site. The section delves into mitigating accidents and risks through proper safety protocols, adequate worker training, and providing the necessary personal protective equipment.

Once the project is operational, the safety of users becomes paramount (Lukhele et al., 2022). This section explores strategies for ensuring safe building or infrastructure use, including emergency protocols and ongoing maintenance to avoid potential hazards.

In the dismantling of a project, safety requires careful consideration. This section discusses the challenges of dealing with harmful materials like asbestos during decommissioning. Strategies for safe removal and disposal of these materials are explored. A real-world example, the La Scala Opera House Asbestos Deaths case, is used to illustrate the potential consequences of neglecting safety during decommissioning (ACTS FACTS, 2016).

3.2.5 Equality, diversity and inclusion

The "Equality, Diversity and Inclusion" section emphasises the importance of creating a level playing field for everyone affected by a project. The section introduces the concepts of inclusive design and how it can address the needs of diverse populations. It discusses the medical vs social model of disability, highlighting the importance of designing for user capability rather than focusing on limitations (Field et al., 2022; Hao et al., 2023).

In design and planning phases, the focus is on designing with accessibility in mind from the start. This involves considering the needs of people with disabilities during building, transportation, and urban planning projects. The section uses a real-world case study, "Trans-inclusive sanitation", to illustrate the importance of inclusive design for all genders and identities.

As for development and construction, the section discusses potential gender inequalities within the construction sector. Then, for operation and maintenance, the focus shifts to ensuring equitable access to the benefits of a project throughout its operation. This involves discussions around energy poverty and strategies for

ensuring affordable access to energy for all communities. Additionally, the section explores the ethical obligation to provide universal access to clean water, a basic human right.

The decommissioning stage part addresses the potential negative impacts of demolition on socio-economically disadvantaged communities. Strategies for mitigating these impacts and ensuring a just decommissioning process are discussed.

3.2.6 Decolonisation

This section delves into the historical and ongoing power imbalances within the engineering profession. It examines how engineers can approach their work ethically in a globalised world. It raises questions about the ethical implications of engineering projects in former colonies and explores how to avoid perpetuating power imbalances.

For design and planning, the focus is on ethical considerations when working in foreign settings. This involves discussions about understanding the local context, respecting cultural norms, and acknowledging existing power imbalances between the Global North and South.

For development and construction, the chapter tackles the ethical challenges of modern slavery and global exploitation within the construction industry. Strategies for ensuring fair labour practices and preventing human rights abuses during project development and construction are explored.

Additionally, the ethical dilemmas surrounding the maintenance of colonial-era urban and infrastructure projects are addressed. The section discusses the challenges of balancing historical preservation with the need for modernisation, and how to ensure these projects benefit the local population. A real-world example, the Central Corridor project in Tanzania, is used to illustrate these complexities.

Finally, this section concludes by discussing issues related to minimising environmental impact and ensuring responsible disposal of materials during decommissioning in formerly colonised countries.

4 SUMMARY AND ACKNOWLEDGEMENTS

This article explored ethical issues in civil engineering across project stages, as included in the Chapter on Civil Engineering of the Routledge International Handbook on EEE. While vast and complex, it serves as a starting point for considering ethical responsibilities in education and practice. The chapter emphasises the full project life cycle and key factors for ethical decision-making. Civil engineers need to navigate individual and collective ethics in a changing world.

This chapter is just a glimpse into a complex topic. For responsible practice, a deeper understanding of these ongoing challenges is crucial. We hope that the chapter inspires further exploration and a commitment to ethical and sustainable engineering.

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