

What are the impacts of material transportation to the sustainability of urban construction projects and how can improvements be made?

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ABSTRACT

This research paper aims to explore the effects that the transportation behind the delivery of construction materials and components has on the sustainability of urban construction projects. In addition, it is aimed to provide an insight into how improvements and developments can be made within the associated processes of material transportation.

This is an important issue to understand and is increasingly relevant due to challenges and targets imposed upon the construction industry worldwide. Construction 2025 is the strategy published by the Government for the United Kingdom. The target areas highlighted within the document all have strong ties to the theme of the research topic within this paper.

Construction 2025 places emphasis on; reducing the costs of construction and usage of built assets, reducing the time taken for project completion, reducing the greenhouse gas emissions within the built environment and finally, reduction in the trade gap between total exports and imports for construction materials and components.

The key objectives of the research question posed are to obtain industry perspective, explore alternatives to traditional methods of delivery through research and to collate data which may assist with forming an opinion on finding the best way forward.

This paper will satisfy the objectives by undertaking mixed methods of research. Firstly, a questionnaire for industry professionals will be used to gain qualitative data. Additionally, a desktop study including the analysis of secondary quantitative data will assist to form a complete picture of the problems faced.

In satisfying the key objectives of the research, a hypothesis can be formed to outline potential means of legitimate methods for improving upon the transportation and delivery of construction materials. This will address the implications faced in terms of sustainability, setting a precedent that should be able to be applied to urban projects globally.

INTRODUCTION

In order to provide a background of the subject matter, it is important to understand the key stages of a construction project as well as the relevance and drive for sustainability within a scheme.

The Royal Institute of British Architects RIBA Plan of Work, as shown below, gives a clear overview and breakdown of the work stages and associated elements that make up a typical construction project.

The RIBA Plan of Work 2020 is a structured framework for construction projects, divided into eight stages. Each stage has specific objectives, tasks, and milestones. The diagram includes a 'Core Strategy' section detailing planning and procurement processes, and a 'Procurement Route' section showing the flow of information and decision-making between client, architect, and contractor.

Stage	0 Strategic Definition	1 Preparation and Briefing	2 Concept Design	3 Spatial Coordination	4 Technical Design	5 Manufacturing and Construction	6 Handover	7 Use
Stage Outcome	The brief needs of addressing the Client Requirements confirmed	Project Brief approved by the client and confirmed that it can be accommodated on-site	Architectural Concept approved by the client and aligned to the Project Brief	Architectural and engineering information Spatially Coordinated	All design information required to manufacture and commission the project completed	Manufacturing, construction and Commissioning completed	Building handed over. Aftercare initiated and Building Contract concluded	Building used, operated and maintained efficiently
Core Tasks	Project Client Requirements. Develop Business Case for feasible scheme including review of Project Brief and Project Budget. Ready when the brief is confirmed by the client	Project Project Brief including Project Outcomes and Sustainability Outcomes. Quality Assurance and Client Feedback. Review Project Budget. Agree Project Brief. Source Site Information including Site Surveys. Undertake Site Appraisal	Project Architectural Concept incorporating Strategic Engineering, Quality Assurance and Client Feedback. Review Project Budget. Agree Project Brief. Source Site Information including Site Surveys. Undertake Design Review with client and Project Stakeholders. Prepare Project Execution Plan	Undertake Design Studies, Engineering Analysis and Client Comments to test Architectural Concept. Spatially Coordinated design aligned to client's Cost Plan. Project Stages and Outline Specification. Issue Change-Control Procedures. Prepare stage Design Programme	Develop architectural and engineering technical design. Prepare and coordinate design team Building Systems Information. Prepare and integrate Building Systems Information. Prepare stage Design Programme	Finalise Site Logistics. Manufacture Building Systems and construct building. Monitor progress against Construction Programme. Impact Construction Quality. Resolve Site Queries as required. Undertake Commissioning of building	Finalise building in line with Plan for the Strategic Performance. Undertake review of Project Performance. Undertake seasonal Commissioning. Verify Project Outcomes including Sustainability Outcomes	Project Facilities Management and Asset Management. Undertake Post-Occupancy Evaluation of building performance. Verify Project Outcomes including Sustainability Outcomes
Core Strategy	Strategic appraisal of Planning considerations	Source pre-application Planning Advice. Initiate consultation of health and safety Pre-construction Information	Obtain pre-application Planning Advice. Agree route to Building Regulations compliance Planning Application	Review design against Building Regulations. Prepare and submit Planning Application	Submit Building Regulations Application. Discharge pre-construction Planning Conditions. Prepare Construction Phase Plan. Submit form F10 to HSE if applicable	Comply with Planning Conditions as required	Comply with Planning Conditions as required	
Procurement Route	Traditional Design & Build 2 Stage	Design & Build 2 Stage	Design & Build 2 Stage	Design & Build 2 Stage	Design & Build 2 Stage	Design & Build 2 Stage	Design & Build 2 Stage	
Information Exchanges	Client Requirements Business Case	Project Brief Feasibility Studies Stakeholders Project Budget Project Programme Procurement Strategy Responsibility Matrix Information Requirements	Project Brief Designations Project Strategy Project Outlines Outline Specification Cost Plan	Signed off Stage Report Project Strategy Signed Off Outlines Specification Client's Cost Plan Planning Application	Manufacturing Information Final Specifications Result Project Stages Building Regulations Application	Building Manual including Health and Safety File and Fire Safety Information Practical Completion certificate including Defects List Asset Information	Final Certificate Feedback from Client Post-Occupancy Evaluation	Feedback from Post-Occupancy Evaluation Updated Building Manual including Health and Safety Report of Fire Safety Information as necessary

A simplified breakdown of a construction project may entail the following: Concept Stage, Design Stage, Construction Stage and Operation Stage.

Planning for sustainability within projects will be completely dependent on the priorities of a client team and is likely to vary due to scale, complexity, and the budget of proposed developments. The desired levels of

sustainability influenced throughout the project can stem from the concept stage and can be classified as four key attributes. The attributes include awareness, concern, motivation, and implementation. (Royal Institute of British Architects (2020))

Awareness is relative to knowledge based upon sustainability and the understanding of the negative impacts that will be caused as a direct result of proposed works and processes.

Concern is the level of thought, care, and sense of responsibility taken due to awareness.

Motivation is the desire to act and see improvement within planned construction procedures.

Implementation is the actual undertaking of a plan put in place to deal with concerns in the hopes of minimising negative impacts of the proposed construction works. It is the willingness to sacrifice time, money, and effort to initiate change and make a difference.

Transportation and logistics play a large role in the successful delivery of construction projects no matter the size. The greater the complexity of schemes, the greater emphasis there is on transportation and logistical impacts.

LITERATURE REVIEW

Questionnaire

The main component, guiding the research for this paper is the questionnaire produced with the purpose of gathering knowledge and insight from construction industry professionals on key talking points related to the research aims. The questions posed have been designed to gain respondents general understanding and beliefs on the subject, regardless of both their level of professional experience in the area as well as whether their opinion is optimistic or skeptical.

Government Guidance

There is one piece of relevant Government guidance relating to this research topic, this is the Construction 2025 initiative, set up by the Government in 2013. However, currently there is no specific guidance that relates to the transportation or delivery of construction materials and no legislation exists which enforces a move towards sustainability. This appears contradictory in the quest for sustainability, due to the sheer volume of construction materials imported and transported across the nation. Also, clearer enforcement of construction transportation sustainability would have better complimented other sustainability introductions, such as Clean Air Zones and Ultra Low Emission (ULEV) Business vehicles. Although, the Construction 2025 guidance does outline targets set by the Government, so while changes are not legally enforced, they are massively encouraged to allow for succeeding with ambitious targets. But this leaves potentially a grey area, where the industry is unsure and unsupported in moving towards sustainability.

Related Articles and Publishments

Two articles have been found that bare relevance to the content to this research. The first article is 'Environmental Impact of Construction Transport and the Effects of Building Certification Schemes' published by Linkoping University on 1st June 2021. The second article, 'Building Bridges: A Participatory Stakeholder Framework for Sustainable Urban Construction Logistics' was published on the 2nd March 2021 by Vrije Universiteit Brussel. With both articles being published in 2021 it can be guaranteed that the information contained within these papers are relevant at present day and should complement the research topic.

'Environmental Impact of Construction Transport and the Effects of Building Certification Schemes'

The Linkoping University paper was produced to investigate the environmental impact of construction transport and whether the building certification scheme for a construction project has any influence on transport arrangements. Within the publication, forty Swedish projects were analysed as case studies to form the basis of research. The study contributes to a better understanding of construction transport patterns and reducing environmental harm of these transports.

The primary research being undertaken aims to build upon the findings of the Linköping paper. However, research methods differ largely, with the primary research focussing on the identification of all transportation impacts on the potential sustainability of urban construction projects via an open-ended questionnaire.

‘Building Bridges: A Participatory Stakeholder Framework for Sustainable Urban Construction Logistics’

The Vrije Universiteit article is more alike to the research being undertaken within this paper from a topical point of view. The article aims to present a participatory decision-making framework for the governance of urban construction logistics on an economic, environmental, and societal levels. Although like the research paper being produced it focuses less on material transportation impacts to the sustainability of projects and leans more into providing formulated solutions for logistics within urban construction projects depending on project constraints and stakeholder criteria.

The heavier analytical characteristics of the Vrije Universiteit publication will both contrast and compliment the research style of this paper as it can contextualise in figures the viability of alternative methods of material transportation and logistics.

General Research

Further to the areas of research headed above, generalised contextual research has also been undertaken. This research mainly relates to alternative methods of material transportation, statistical data linking to government guidance and an incorporative overview of sustainability within construction projects.

RESEARCH REVIEW

Table 1.1 Four Worldviews	
<p>Postpositivism</p> <ul style="list-style-type: none"> • Determination • Reductionism • Empirical observation and measurement • Theory verification 	<p>Constructivism</p> <ul style="list-style-type: none"> • Understanding • Multiple participant meanings • Social and historical construction • Theory generation
<p>Transformative</p> <ul style="list-style-type: none"> • Political • Power and justice oriented • Collaborative • Change-oriented 	<p>Pragmatism</p> <ul style="list-style-type: none"> • Consequences of actions • Problem-centered • Pluralistic • Real-world practice oriented

When considering approaches to research there are multiple philosophical world views which hold potential for informing and influencing research design and methods of research. Research Design by Creswell and Creswell (2018) outlines a framework for design, providing ways in which approaches could be produced. This will form the primary source of information for the conclusion of the formulated approach to satisfying the research question.

The four main worldview philosophies are: Postpositivist, Constructivist, Transformative and Pragmatist. Table 1.1 (Creswell & Creswell, 2018) as displayed above shows the main themes for each worldview. The two worldviews relating closest to the research subject are constructivism and pragmatism.

Constructivism enables the compilation of information sampled from different sources to generate a wider understanding of matters and to develop a theory as to why issues are current and what can be done to resolve them and further develop the situation.

In addition to gathering qualitative data by means of distributing a questionnaire to construction industry professionals and examining related articles, generalised contextual research has also been undertaken. This research ties into the logic and approach towards sustainability within construction projects as well as looking at different means of transporting and distributing construction materials in a sustainable fashion.

A Pragmatic overview is an alternative style of research for the paper. Pragmatism focuses on and emphasises the research problem and question at hand, taking advantage of all the available approaches to understand the matters. It can be determined that the pragmatic world view bares the greatest relevance to the research subject, allowing the individual researcher a greater depth of choice when considering research approaches and methods best suited to the specific needs of the research paper.

A pragmatic approach naturally lends itself to handling real world issues. With relevance of the subject matter established from the outset, pragmatism means data obtained can be focused on in a simple and more direct manor than alternative worldview philosophies. Incorporating pragmatism means that the paper will not be subject to restrictions in respect of research design. Therefore, it is possible to utilise whichever research methods are considered beneficial in addressing the research question and developing the paper itself.

Taking the above into consideration, a mix of both qualitative and quantitative research would be best suited to the subject matter and produce the clearest outcome. This is because qualitative data, received from questions answered by professionals within the construction industry helps portray varied and realistic interpretations whilst the analysis of secondary quantitative data obtained through a desktop study can provide statistics to further evidence issues raised.

The rationale behind using a questionnaire directed at professionals within the construction industry as the basis for the research findings is that analysis can be undertaken on genuine, unbiased responses to specific topical questions. This type of data can only be produced organically, not using figures and statistic alone. However, as mentioned, secondary quantitative information will assist in the production of a conclusion and will be complimentary to the qualitative data obtained.

RESEARCH METHODOLOGY

As outlined within the 'Research Review', the methodology for this study initially involves undertaking a questionnaire answered by construction industry professionals to collect qualitative data. Furthermore, a desktop study is to be carried out which will allow for the analysis of external research papers linked to the aims of this paper and for the analysis of secondary quantitative data, within the existing publications or through other, general research.

Utilising pre-existing knowledge allows for a greater insight into points and arguments raised, this kind of information further encourages discussion and exploration of matters and key talking points. Having reviewed existing publications, the originality of the developed research paper will be displayed, comparisons and differences can be acknowledged and perhaps used as a basis for broader research. Additionally, generalised research is to be undertaken within this paper to explore sustainability within the construction industry generally.

The thought process behind adopting a mixed methods research style is due to the notion that context, provided via secondary research, is key throughout this paper. Mixed methods mean qualitative and quantitative as well as primary and secondary approaches can be combined to best satisfy the research aims. The broader research combined with the expressed opinions of industry professionals, provided via the questionnaire, provides the greatest detail for answering the aims of the research and gives a confidence in quality that may not have been achievable otherwise.

It is important to note that due diligence has been taken to validate the accuracy, authenticity and relevance of information sampled. This is crucial when producing a research paper as the validity of results and findings depend upon integrity. Having considered this, it can be confirmed that any information used within the bounds of the paper is genuine. All questionnaire responses have been received from willing participants working within the construction industry. Existing articles referenced were published by The Department of Science and Technology, Linköping University of Sweden and Mobility, Logistics & Automotive Technology Research Centre, Vrije Universiteit Brussel of Belgium respectively. Both sources of existing research articles are universities and have credible and respectable reputations.

RESEARCH RESULTS

Industry Professional's Questionnaire – Questions and Feedback

Q1 - In your opinion do you think supply of construction materials has improved or worsened since 2013 (inception of Construction 2025 government plan)?

In this simple, multiple-choice question 60% of participants stated improved and 40% stated supply has worsened since 2013. The reasoning for the respondents decisions is explored in Q2.

Q2 - What do you think are the highest contributing factors to the answer provided above?

Respondents stating supply had improved suggested improved supply networks, better automation and distribution technologies, delivery vehicle enhancements, road network enhancements, increased demand, increased distribution hubs and better emphasis on project planning and management had supported the improved supply of construction materials. Contrastingly, those stating supply of construction materials had worsened suggested COVID-19 Pandemic and Brexit as the major setbacks in supply.

Q3 - In your experience are there any construction materials in particular that are frequently used and require specialist delivery to site? (If yes please note which)

Materials mentioned included large structural framing components, large scale prefabricated elements and systems which include modular components.

Q4 - What is your level of understanding of non-traditional transport and distribution methods?

Q4 was a further multiple-choice question, with three possible answers: advance, moderate and none. No respondent claimed to have an advance understanding, 40% claimed to have a moderate knowledge level and 60% admitted to having no knowledge. This could demonstrate that people working within the construction industry may not have a solid understanding of the complex processes in material transportation and its implications with sustainability, a fact which may hinder improvements being made.

Q5 - Are you aware of any increased sustainability/environmentally friendly transportation or distribution methods for construction materials? (If yes please note which)

A vast majority specified alternative fuels or energy for powering delivery vehicles as the way of increasing sustainability in transport. However, there were three separate answers which stood out and listed local supply, construction consolidation centres and just-in-time procurement as methods of increasing sustainability.

Q6 - Do you think the company you work for would desire to be associated with sustainable transportation methods within their projects? (If yes why?)

93% of participants answered yes with most responses justifying the answer stating that being sustainable holds reputational and educational benefits, for individuals and the company. However, two responses expanded and stated functional benefits of sustainability can be seen in projects, quotes from these responses are below:

- “Lend itself well to the embodied energy of projects that are undertaken with the RIBA 2030 climate challenge in mind.”
- “Soon I believe contractors and their supply chains will need to collate total embodied carbon for all materials delivered to site, to give a total at the end of a project. There will be pressure to reduce as much as feasibly possible through increased collection of data...Without this data capability, contractors will not be selected for Government funded schemes.”

Q7 - Do you think sustainable transportation of materials is likely to be adopted within projects, even if it came at a more significant cost? (Please explain why)

50% participants stated yes, 40% answered no and 10% stated it was a possibility but it depended on multiple other factors. The main two reasons respondents said more sustainable materials would not be adopted was due to lowered profitability and that there is no incentive or legislation into persuading people to using more sustainable options. This is an issue mentioned in the literature review.

Q8 - What kind of benefits could you/your company see to updated methods of construction material transportation?

Similarly, to to Q6, reputational and educational benefits were highlighted. The key benefit noted was reduction of CO₂ emissions, which is increasingly important on urban projects.

Q9 - Do you think it would be difficult to improve the traditional methods of transporting construction materials and components? (If yes how?)

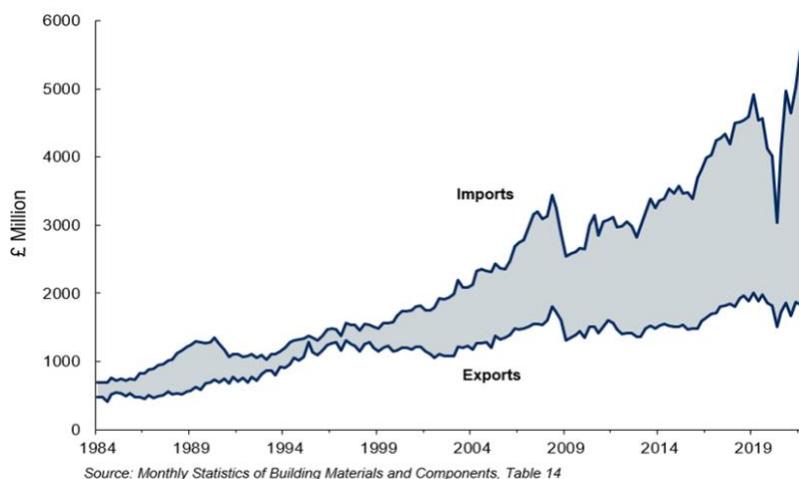
90% of respondents concluded that they thought it would be difficult to implement improved methods of material transportation. Within the responses there was one which provided a good summary of why the 90% claimed implementation would be difficult:

- “I think it will be very hard, until something in stature, then most clients will be thinking of bottom line for all stakeholders. Majority of clients still don’t adhere to CDM 15, and has been around for 7 years now. Unless a client must obtain a certificate such as planning or building regulations (something the have to do in Stature) then they will ignore their CDM duty. I think the same goes for sustainability.”

Analysis and Reaction to Questionnaire Feedback

Q1 and Q2

There are four main goals set by the Construction 2025 strategy. Those goals are 50% improvement in material exports and 50% lower emissions within the UK construction sector.



The above graph is dated until the first quarter of 2022. As displayed, since 2013 sufficient progress has been made to satisfy the material exports target which must now be maintained until 2025.

Also, immediately it is evident that material imports have increased on a much larger scale than exports since 2013.

Importing such large quantities

of materials from other countries will inevitably impact on transportation sustainability. This contradicts the target to reduce emissions. The large downwards spike shown within the

imports line during 2020 correlates with Brexit and the COVID-19 pandemic, as noted within the Q2 responses where some respondents stated supplies had worsened due to these global events. (Government UK, 2022)

Q3, Q4 and Q5

Ultimately the answers provided for Q4 show a lack of knowledge, even within the industry which reinforces the point made about a lack of understanding surrounding Government guidance in the literature review. Guidance has not been updated nor have any new guidelines been released so it can be deemed that there is not enough awareness or emphasis placed around sustainability in construction. And even when guidance is clear, there isn't necessarily motivation to make changes.

Analysis of Q5 responses allows for further investigation into sustainable transportation and distribution of materials within urban construction projects. Two of the three responses of interest which could be considered most viable within urban projects are construction consolidation centres and just in time procurement.

A construction consolidation centre is a distribution facility that can be used in the process of managing project logistics, channelling material deliveries to a large, single construction site or a number of different sites. It facilitates the efficient flow of materials through the supply chain, reducing waste and other issues such as congestion. Just In Time is a production and delivery system that ensures materials and components are delivered from the manufacturer to the project site at exactly the right moment to enable immediate use within the development process. (www.designingbuildings.co.uk. (n.d.))

Taking Q3 into consideration, larger, more specialized construction elements will usually be designed specifically for a project and are more likely to come direct from a manufacturer. This would mean a CCC wouldn't be an option however the manufacturer could adopt a JIT approach.

Q6, Q7, Q8 and Q9

The utilisation of sustainable approaches and technologies are certainly related to the monetary side of projects with budget, profit margins and perceived end user benefits usually being driving factors as to the level of sustainability the project can meet. Socially there is a large narrative within the construction industry currently that promotes the use of sustainable approaches and technologies within projects. Regarding social impacts on projects, the level of sustainability within a scheme can have a direct correlation with its desirability and acceptance on both a local and national scale. Not only can a specific project benefit in terms of perception but the client and associated consultants also have the potential for commendation due to their efforts in supporting sustainability. With a focus on urban projects, these factors can only be exacerbated by increased targets for air quality, congestion and the conservation of wildlife and habitats within towns and cities.

DISCUSSION

Overall, it can be established that this research paper takes a much different approach to the articles produced by Linköping University and Vrije Universiteit. Both referenced papers are statistically heavy and benefit from more advanced research, as seen in their length, however the point and purpose of this research was to gain and present insight from UK industry professionals to identify constraints within the sustainable delivery of construction materials within urban construction projects and outline potential improvements and ways forward. It can be seen through analysis of research findings that action points are discussed for the development of the research subject topic. Although the sample group of research participants was reasonably low at thirty members of industry it can be seen that with greater planning, research time and no restriction to length, widescale research could be carried out building upon the foundation of this paper.

CONCLUSION

The research and findings of this paper generally show the lack understanding towards sustainability within the construction industry, it is clear that the full potential of sustainable projects is a long way from being unlocked. People may be conscious that targeting sustainability within works may provide a good social image but it is clear that further education is needed from the government so that they themselves can release newer guidance with updated targets and maybe even legislative documents. Until that point, the lack of legal enforcement and the desire for profit and pleasing stakeholders means that sustainability will often be sacrificed, almost as a nice to have rather than a must have.

It would be good to research further into the reasons industry members lack understanding, when they work within a field where sustainability is emphasized greatly. It would also be good to find out what a better way to see the change on the ground would be as we get closer and closer to government targets. It would also be interesting to see further research exploring whether there needs to be a better collaboration with other industries, like logistics, to lock in sustainability gains. E.g. trucks are not sustainable, but are the mass option.

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