Tampere University

Hiilineutraalit energiaratkaisut ja lämpöpumppputeknologia (HybE)

Research Sprint Report

Exploring Characteristics of Deep Collaboration and Investigating Impacts of Collaborative Delivery Models on the Productivity and Environmental Sustainability of Construction Projects

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List of key terms and concepts

The list of key terms and/or concepts, utilized in this report, are explained in the following table.

Key term/concept	Explanation
Collaborative construction projects	All parties, with aligned interests and mutual trust, work together (collaboration) and exchange information (cooperation) for the best of the project. Construction projects with collaborative delivery models (e.g., alliance, partnering, integrated project delivery) and/or traditional delivery models (e.g., design-build) equipped with collaborative practices (e.g., integrated team) represent collaborative construction projects.
Collaborative delivery models of construction projects (e.g., alliance, partnering, integrated project delivery)	Joint design, planning, management, and governance of construction projects by the key parties based on their early involvement in the project, trust-based relationships, open communication, and shared risk-reward systems. Collaborative delivery models are different from the traditional ones (e.g., design-bid-build, design-build) in: (i) Focus (on the production system, not the transactions and contracts), (ii) Design and planning (product and process are designed together, not separately; activities are performed at the last responsible moment, not as soon as possible; buffers are used to absorb system variability, not for the local optimization), (iii) Decision making (unanimous, not divided), (iv) Learning (occurs continuously throughout the project, not sporadically), (v) Stakeholder interests (aligned).
Alliance	A multiparty contracting arrangement between two or more parties, undertaking the project cooperatively on a shared risk and reward basis for the purpose of achieving agreed outcomes based on principles of mutual trust, open-book approach toward project costs, a commitment to no-disputes, best-for-project, unanimous decision-making processes, a no fault-no blame culture and a joint management structure.
Integrated project delivery (IPD)	A multiparty/polyparty agreement and trust-based collaboration among project parties, which seeks to improve project outcome in result of aligning incentives and goals of the project team through early involvement of them in the project and a shared risk-reward approach.
Partnering	Formation of a project team to deliver a construction project; the team commits to open communications in a spirit of trust, and works to accomplish mutual project goals. Partnering itself is not a contract. Partnering focuses on improving traditional contractual frameworks such as traditional contracting and design and build. Partnering is a collaborative procedure and is not legally binding. A partnering charter is developed to run in parallel with a traditional construction contract to provide guidelines to the relationship among the organizations. Parties agree to act reasonably and fairly. Partnering relies solely on the commitment of individuals, as the partnering charter is not legally binding—and this can be its best or worst feature.

Traditional construction projects	Construction projects with traditional delivery models. Traditional delivery models are explained in the following.
Traditional delivery models of construction projects (e.g., design build, design-bid-build)	Traditional models and processes for design, planning, management and governance of construction projects, where there is usually a clear separation between design and construction phases which isolates the contractor from the design process. Moreover, the lowest construction price is usually the most important criteria for selecting the contractor which represents the potential ability, in theory, for delivering a low cost project.
Design-Bid-Build (DBB)	The most frequently used type of delivery model for construction projects, where the project parties are the owner, the designer and the contractor. The owner conceptualizes the project, and planning as well as programming are carried out by the agents of the owner (such as architects/engineers or construction managers) based on the objectives to be met. Consequently, the scope of the project, preliminary budget, and schedule are derived. The detailed design is usually undertaken in stages, resulting in the preparation of completed drawings and specifications, representing bid documents as well as detailed cost estimates. Bid analysis is carried out and a legally binding contract is then awarded. The contractor is given access to the site and instructed to proceed, based on legally established time frames. A contract may contain incentives for timely completion, as well as penalties for avoidable delays or cost overruns. At completion, there are acceptance inspections, leading to the commissioning of the facility for the
Design-Build (DB)	Accelerates project delivery through concurrent design and construction activities. A DB project, like DBB ones, is conceptualized by the owner; planning is carried out based on the objectives to be met, and on the economic and technical feasibility of the project. The best time for site acquisition is as early as possible to ensure that the design will not have to be aborted. Planning and schematic design are undertaken by the owner's design professional. This information allows construction to start shortly after contract award, while the design builder continues the preliminary design to obtain a final design. Typically, the design professional develops a preliminary design and cost and schedule proposals for the overall project. The design builder is given access to the site and instructions to proceed, based on legally established time frames. This type of contract may also contain incentives for timely completion, as well as penalties for avoidable delays or cost overruns.
Engineering-Procurement-Construction (EPC)	Like DB projects, most of the design and construction functions are performed or managed by one organization. This model, however, is used primarily for industrial projects that emphasize engineering design, as opposed to architectural design. The EPC projects typically have commissioning and maintenance phases included to allow for a plant to reach its designed operating capacity after acceptance.

Construction Management (CM)	Allows an owner to engage a construction manager during the design process to provide constructability input. The Construction Manager is generally selected on the basis of qualifications, past experience or a best-value basis. During the design phase, the construction manager provides input regarding scheduling, pricing, phasing and other input that helps the owner design a more constructible project. At approximately an average of 60% to 90% design completion, the owner and the construction manager negotiate a "guaranteed maximum price (GMP)" for the construction of the project based on the defined scope and schedule. If this price is acceptable to both parties, they execute a contract for construction services, and the construction manager becomes the general contractor. The CM/GC delivery method is also called the Construction Manager at-Risk (CMR).
Source: Moradi, S. *Project Managers' Competencies in Collaborative Construction Projects*. Ph.D. Thesis, Tampere University, Tampere, Finland, 2021. Available online: http://urn.fi/URN:ISBN:978-952-03-2002-7.	

Introduction

The successful performance of construction projects considerably depends on the delivery model that is selected for completing the project (Mostafavi and Karamouz, 2020). Construction project delivery models have been a means of accomplishing project definition, design, planning, and execution phases by specifying the contractual relationships and allocating the risks and rewards of the project to the key parties. This perspective can be helpful in understanding the terminology associated with the traditional construction project delivery models (e.g., design–bid–build; design–build, engineering–procurement–construction) which represent an emphasis on the division. This means that dividing the construction project phases between the key parties based on their contractual responsibilities usually results in their separation and working in their own silos throughout the project.

For instance, the contractor in traditional construction project delivery models is usually not involved in the project definition, planning, and design, or at least, this involvement is not early enough. The explained division consequently causes a few disadvantages associated with the traditional delivery models of construction projects. Some of these disadvantages are the late involvement of key project participants, the lack of integration, several design errors and reworks, litigation and claims, cost, and time overrun as well as mistrust and adversarial relationships (Hauck et al., 2004; Matthews and Howell, 2005; Moradi et al., 2022). It can be argued that the mentioned challenges have been the main drivers of the changes and developments that have happened in construction project delivery in the last four decades (Forbes and Ahmed, 2010).

The mentioned changes and developments, in the holistic view, account for the shift from traditional delivery models to the collaborative ones (alliance, partnering, integrated project delivery, lean project delivery). The common features of collaborative delivery models include the early involvement of key parties, shared risk–reward, joint project planning and control, jointly developed and validated goals, and trust-based relationships for collaboration and cooperation (e.g., Fischer et al., 2017; Oakland and Marosszeky 2017; Moradi et al., 2021). Accordingly, collaborative delivery models are usually characterized by limited change orders, reduced liability exposure, fixed profit, and profit based on project outcome, unlike traditional delivery models.

In construction projects with collaborative delivery models, project participants work together (collaboration) and exchange information (cooperation) with aligned interests and mutual trust for the best of the project. Construction projects with collaborative delivery models have had promising performance results compared to traditional ones, particularly in terms of time, cost, and quality (e.g., Ibrahim et al., 2020). In addition, there have been anecdotal evidence that collaborative project delivery models (e.g., alliance) contribute toward better environmental sustainability (higher energy efficiency and less emissions) in construction projects. This has led to a growing trend of using collaborative delivery models and working practices in construction projects in many countries (for instance in the USA, UK, Australia, and Norway).

In Finland, almost 100 construction projects with collaborative delivery models (e.g., alliance) have been launched since 2011 with a total value of EUR 5.5–6 billion (Moradi et al., 2021). However, there is very limited, if any, research which has tried to address the performance of the completed collaborative delivery models in Finland in the past 10 years. Hence, it is imperative to explore characteristics and realization mechanisms of deep collaboration and to investigate impacts of collaborative delivery models (alliance in particular) on the productivity and environmental sustainability of construction projects.

In the following sections, the terms collaborative construction projects and traditional constructions projects, wherever used, refer to the construction projects with collaborative and traditional delivery models, respectively.

Research questions and objectives

The research questions and objectives of this are shown in Table 1.

Table 1. Research questions and objectives

Research questions	Research Objectives
1. What are the characteristics and realization mechanisms of deep collaboration in construction projects?	1. Discovering the characteristics and realization mechanisms of deep collaboration in construction projects.
2. How the performance of completed alliance type construction projects have been in terms of time, cost, safety, and stakeholder satisfaction?	2. Investigating the performance of completed alliance construction projects in terms of time, cost, quality, safety, and stakeholder satisfaction.
3. How the performance of completed alliance type construction projects have been in terms of environmental sustainability (i.e., energy consumption and emissions)?	3. Investigating the performance of completed alliance construction projects in terms of environmental sustainability (i.e., energy consumption and emissions).
4. Is there any difference between the productivity and environmental sustainability of alliance construction projects and traditional construction projects (e.g., design-bid-build)?	4. Broadening our understanding on the difference between productivity as well as environmental sustainability of collaborative (e.g., alliance) and traditional construction projects.

Research environment

The involved people in this study are shown in Table 2.

Table 2. Research environment

Title and full name of the researcher(s)	Responsibilities in the project
Dr. Sina Moradi	Main researcher and Project manager
Venla Mäkinen	Research Assistant
Jenna Tuominen	Research Assistant
Prof. Piia Sormunen	Supervisor

Methodology

Research design

This study aims to employ mix-method approach for realizing its purposes. To do so, both qualitative and quantitative data collection methods (semi-structured interview and survey) were utilized. The qualitative data were collected from project professionals in Finland and Norway. The quantitative data were collected through a web-based survey (see the questionnaire in Appendix A) in result of which 33 full responses were received. The respondents are from Finland, Australia, Bahrain, Canada, Norway, the UK, United States, Turkey, and Iran. The obtained qualitative data from interviews were analyzed through content analysis method. The obtained data from the survey was analyzed through descriptive statistics.

Demographic information of interviewees

In total, 15 interviews were conducted with project professionals in Finland and Norway from which Norway's share was only one interview. Figure 1 shows the demographic information of the interviewees.

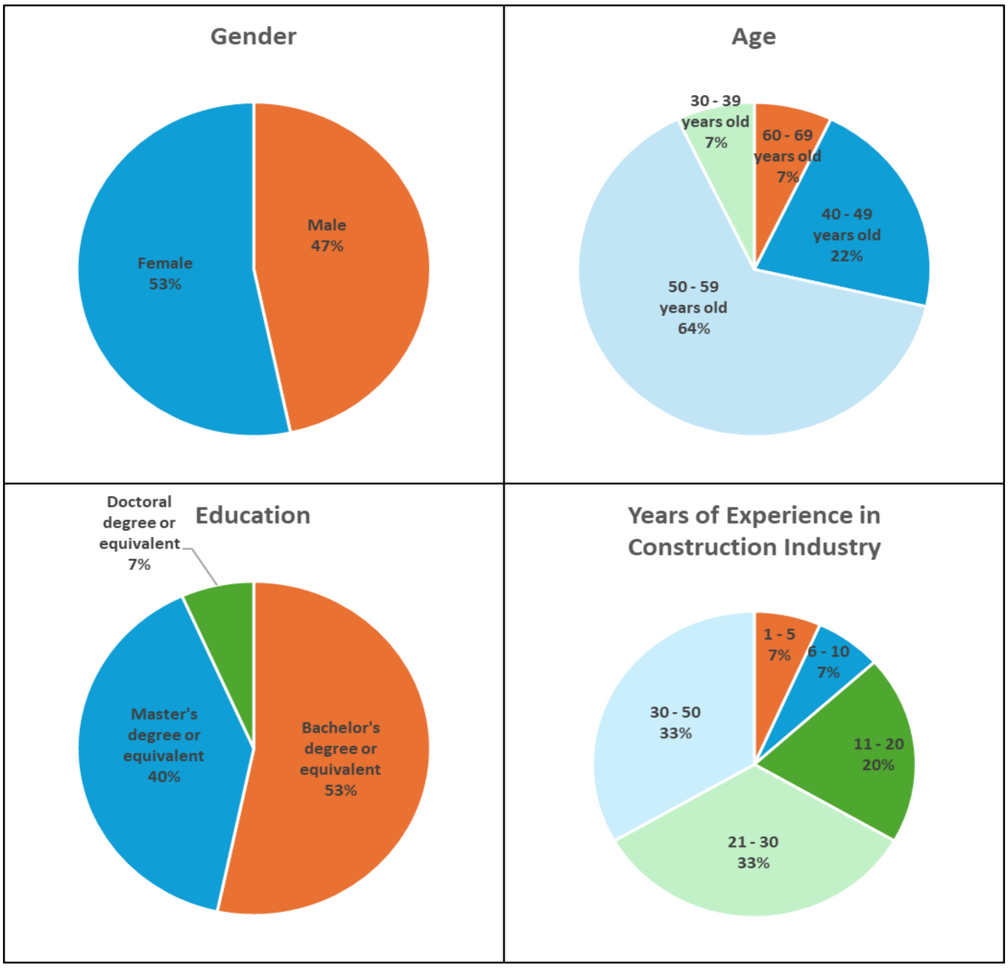

Figure 1. Demographic information of the interviewees

Demographic information of survey respondents

In total, 33 responses were received on the web-based survey. Table 3 and Figure 2 show the demographic information of the survey respondents.

Table 3. Demographic information of the survey respondents

No	Country of residence	Age	Education	Gender	Experience
1	Australia	56	Doctoral degree or equivalent	Male	25
2	Bahrain	25	Bachelor's degree or equivalent	Male	0
3	Bahrain	24	Bachelor's degree or equivalent	Female	3
4	Bahrain	41	Doctoral degree or equivalent	Male	19
5	Bahrain	29	Master's degree or equivalent	Male	5
6	Bahrain	28	Master's degree or equivalent	Female	6
7	Bahrain	35	Bachelor's degree or equivalent	Male	13
8	Bahrain	31	Master's degree or equivalent	Female	9
9	Bahrain	22	Bachelor's degree or equivalent	Male	1
10	Canada	63	Doctoral degree or equivalent	Male	40
11	Canada	35	Doctoral degree or equivalent	Female	15
12	Finland	38	Master's degree or equivalent	Female	15
13	Finland	60	Master's degree or equivalent	Male	40
14	Finland	57	Bachelor's degree or equivalent	Female	0
15	Finland	57	Bachelor's degree or equivalent	Female	23
16	Finland	39	Master's degree or equivalent	Male	12
17	Finland	35	Bachelor's degree or equivalent	Male	23
18	Finland	61	Master's degree or equivalent	Male	34
19	Finland	55	Master's degree or equivalent	Male	30
20	Finland	54	Bachelor's degree or equivalent	Male	30
21	Finland	57	Master's degree or equivalent	Male	40
22	Finland	64	Master's degree or equivalent	Male	45
23	Finland	65	Master's degree or equivalent	Male	43
24	Finland	56	Bachelor's degree or equivalent	Male	32
25	Finland	65	Master's degree or equivalent	Male	38
26	Finland	36	Master's degree or equivalent	Male	13
27	Iran	62	Master's degree or equivalent	Male	41
28	Norway	61	Doctoral degree or equivalent	Male	35
29	Norway	32	Master's degree or equivalent	Male	2
30	United Kingdom	41	Master's degree or equivalent	Male	20
31	United States	55	Master's degree or equivalent	Female	40
32	Türkiye	43	Master's degree or equivalent	Male	20
33	Türkiye	58	Master's degree or equivalent	Male	30

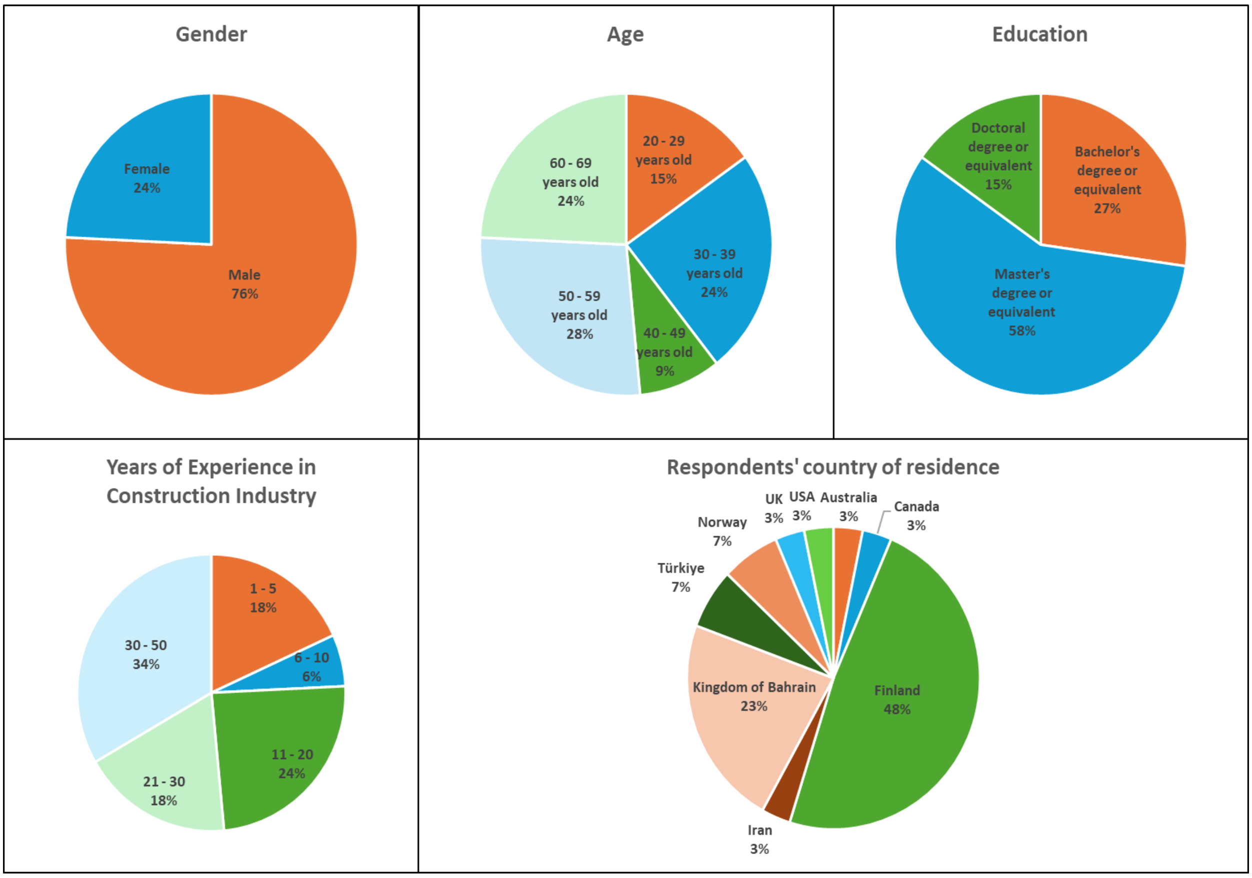

Figure 2. Demographic information of the survey respondents

Demographic information of the survey respondents' latest project

This section shows the demographic information of the survey respondents' latest project, as can be seen in Tabe 4 and Figure 3&4.

Table 4. Demographic information of survey respondents' latest project

No	Delivery model	Project type (i.e., construction category)	Country	Duration (year)	Budget
1	Alliance	Office buildling	Finland	8	220,000,000 €
2	Alliance	Office buildling	Finland	1.5	13,400,000 €
3	Alliance	Hospital building	Finland	4	33,000,000 €
4	Alliance	Gym/sport facility	Finland	3	28,000,000 €
5	Alliance	School/University building	Finland	4	141,000,000 €
6	Alliance	Hospital building	Finland	4.5	231,000,000 €
7	Alliance	Office buildling	Finland	3.5	21,000,000 €
8	Alliance	Hospital building	Finland	3	36,000,000 €
9	Partnering	School/University building	Finland	3	30,000,000 €
10	Partnering	Office buildling	Finland	2	25,000,000 €
11	Partnering	Office buildling	Finland	2	8,300,000 €
12	Partnering	School/University building	Finland	2	85,000,000 €
13	IPD	Gym/sport facility	Finland	6	300,000,000 €
14	CM	Office buildling	Finland	3	80,000,000 €
15	CM	Residential building	Finland	2	17,000,000 €
16	DB	Residential building	Australia	1	500,000 €
17	EPC	Office buildling	Bahrain	1	300,000 €
18	EPC	Residential building	Bahrain	2	330,000 €
19	EPC	Office buildling	Bahrain	2	1,000,000 €
20	EPC	Office buildling	Bahrain	2	1,200,000 €
21	CM	Residential building	Bahrain	3	-
22	IPD	Residential building	Bahrain	1.5	-
23	DBB	Office buildling	Bahrain	2	20,000,000 €
24	LPD	Office buildling	Bahrain	1	-
25	DBB	School/University building	Canada	2	-
26	IPD	School/University building	Canada	2	-
27	CM	Residential building	Iran	3	1,000,000 €
28	DB	Hospital building	Norway	2	5,900,000 €
29	Partnering	Gym/sport facility	Norway	7	62,000,000 €
30	DBB	Office buildling	United Kingdom	1	3,000,000 €
31	CM	Office buildling	United States	2	13,500,000 €
32	DB	Residential building	Türkiye	3	2,000,000 €
33	IPD	Shopping mall	Türkiye	3	2,000,000 €

Legend:
IPD: Integrated Project Delivery
CM: Construction Management
DB: Design-Build
DBB: Design-Bid-Build
EPC: Engineering, Procurement, Construction

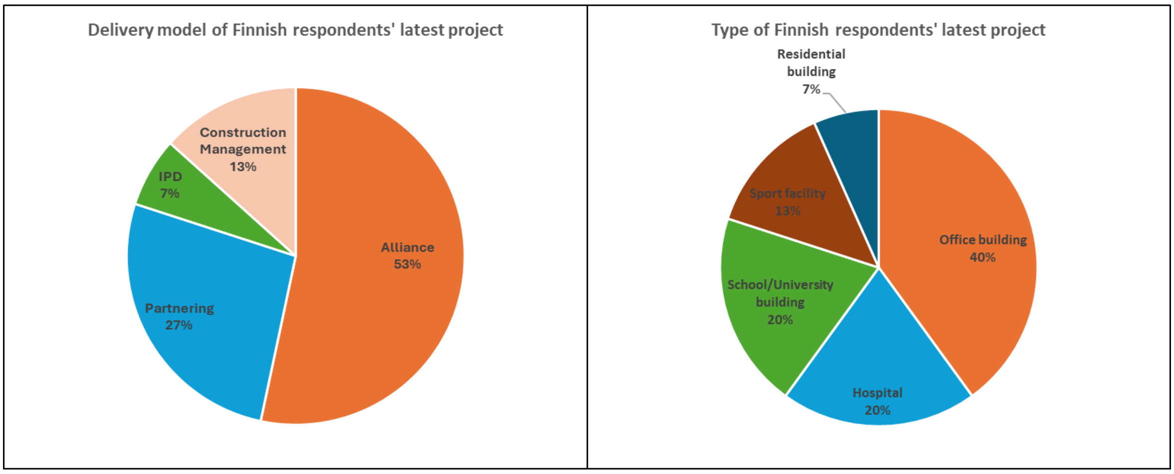

Figure 3. Demographic information of the survey respondents

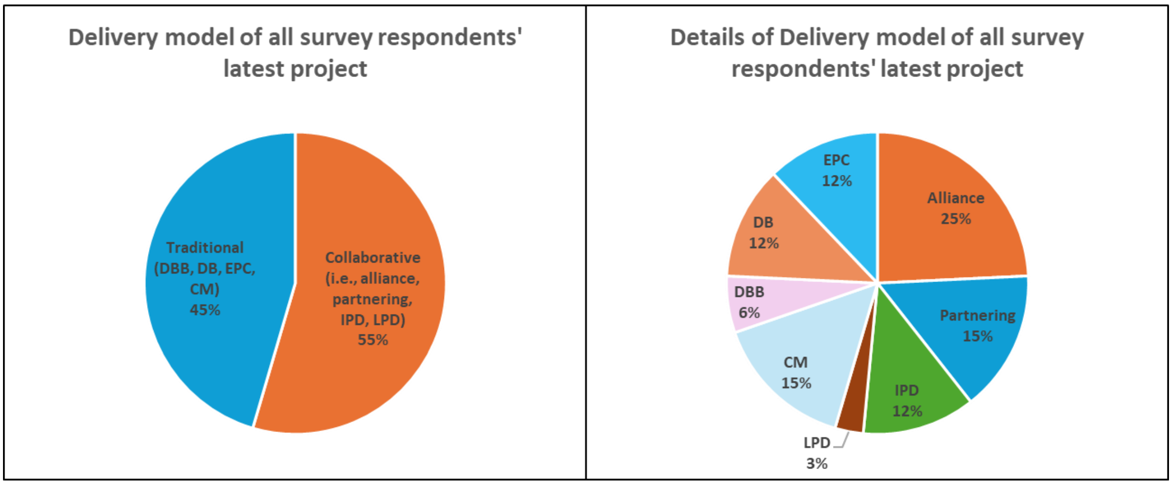

Figure 4. Demographic information of the survey respondents

Analysis

Interview transcripts

Following the completion of interviews, the recordings were utilized for transcribing them. The transcripts were then analysed through content analysis method to explore the characteristics and enablers of deep collaboration and to identify the main factors behind mutual trust in collaborative construction. The analysis was accomplished in three steps. In Step 1, all the questions and answers extracted from the transcripts were listed in Excel Spreadsheet in a manner that all interviewees' answers to the same question can be seen next to each other. In Step 2, the answers to each question were carefully reviewed and the relevant parts of the answers to the given questions were underlined, extracted and listed in separate tables. Then, a synthesis of each table was developed according to the frequency of similar answers given to each question.

Survey data

In total, 33 out of 55 participants fully completed the web-based questionnaire. The survey was open for participation from 4 April 2024 until 15 July 2024. The analysis process started with producing demographic information of the respondents and their latest project which can be seen in the Findings section. Then, the performance of the respondents' latest project was extracted from the survey data and listed in Tables 6 – 12, representing different categories and clusters. Then, the information presentation in those tables were merged and provided a basis for developing two figures (i.e., Figure 7 & 8) which reveal the performance of the reported collaborative and traditional construction projects in terms of time, cost, quality, safety, and energy consumption. In order to objectively evaluate the performance of reported projects by the survey respondents, a scoring system was developed based on which the average scope for performance of collaborative and traditional construction projects, addressed in this study, were calculated. Accordingly, the performance of the reported projects objectively evaluated in a quantitative manner. The details of the scoring logic for each performance category are shown in the Table 5.

Table 5. The details of developed scoring system for objective evaluation of the performance of reported collaborative and traditional construction projects by survey respondents

Performance category addressed in the questionnaire	The question	Valid response options in the questionnaire used for developing scoring scale	Score assigned to each response
Time	Please choose the best statement which applies to the time performance of the project?	The project completed ahead of schedule.	3
		The project completed on time.	2
		The project completed with delay.	1
Cost	Please choose the best statement which applies to the cost performance of the project?	The project completed under budget.	3
		The project completed on budget.	2
		The project completed over budget.	1
Quality	Did the project, upon completion, meet its quality requirements and successfully pass the quality inspections?	Yes	3
		To some extent	2
		Hardly/ Not at all	1
Safety	Did the project complete accident-free?	Yes.	3
		No, there were limited number of minor accidents which resulted in minor injuries	2
		- No, there were several accidents which resulted in minor and major injuries/ No, there was at least one major accident because of which someone died.	1
Energy Consumption in the use phase	Has the constructed building met the energy consumption target in its use phase?	The actual energy consumption of the constructed building in its use phase is less (i.e., better) than the target.	3

		The actual energy consumption of the constructed building in its use is the same as the target.	2
		The actual energy consumption of the constructed building in its use phase is higher (i.e., worse) than the target.	1

Findings

The findings of this research sprint are presented in four sub-sections. Each sub-section answers one of the research questions mentioned in Table 1.

Characteristics and enablers of deep collaboration in construction projects

The first groups of findings reveal nine characteristics of deep collaboration four of which are new and have not been mentioned in the previous studies (see Figure 5). Those four characteristics include financial transparency, problem-solving attitude, active interaction, and good team spirit.

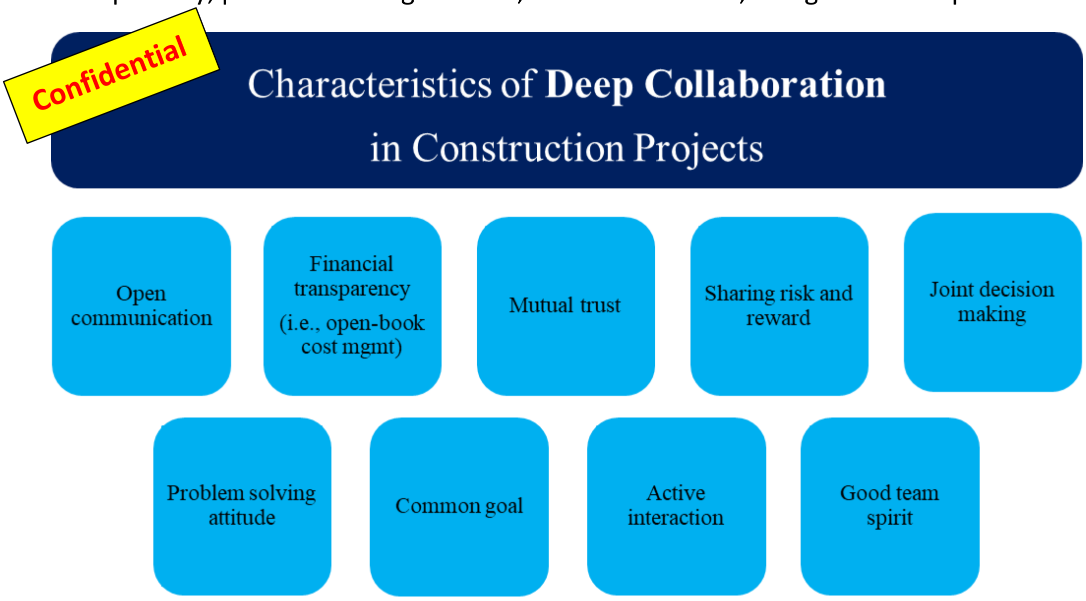

Figure 5. Characteristics of deep collaboration in construction projects (Source: Moradi, S.; Sormunen, P. Deep Collaboration and Mutual Trust in Construction Projects: Views of Nordic Project Professionals. *Building Research and Information* (planned submission: 10 October 2024)

Enablers of collaboration

The second group of findings suggests nine enablers that substantially contribute to the creation of deep collaboration in construction projects (see Figure 6).

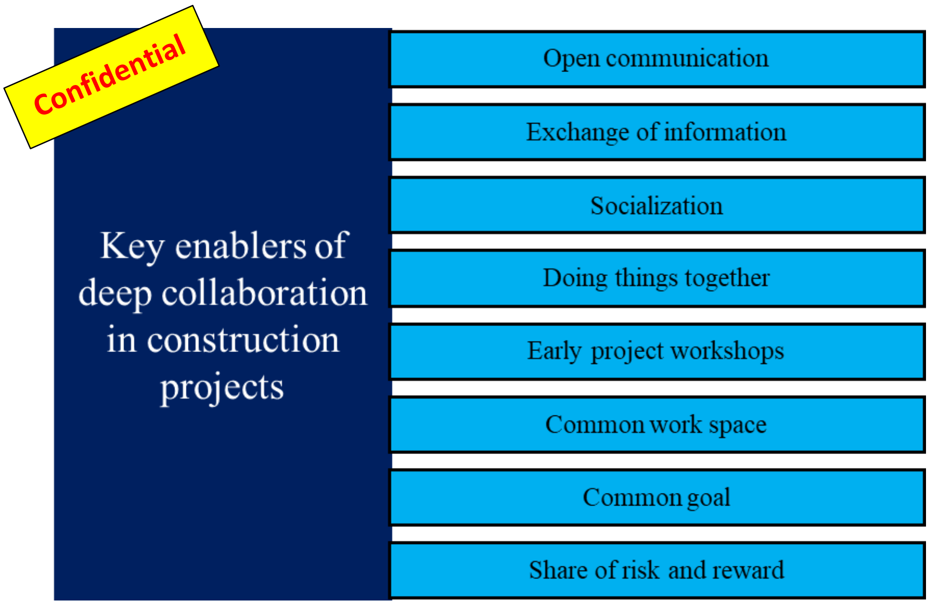

Figure 6. Key enablers of deep collaboration in construction projects (Source: Moradi, S.; Sormunen, P. Deep Collaboration and Mutual Trust in Construction Projects: Views of Nordic Project Professionals. *Building Research and Information* (planned submission: 10 October 2024)

Performance of completed construction projects with the collaborative delivery models

Alliance projects

Among the reported projects by the survey respondents, there were 8 alliance projects and all of them were in Finland. As can be seen in the following, Table 6 shows the performance of those alliance construction projects in terms of time, cost, quality, safety, and energy consumption (in the use phase).

Table 6. Performance of completed alliance projects in Finland in terms of time, cost, quality, safety and energy consumption in the use phase

Performance of completed alliance projects in Finland		
Performance category	Criteria	Number of projects meeting the criteria
Time	The project completed ahead of schedule.	3
	The project completed on time.	3
	The project completed with delay.	2
Cost	The project completed under budget.	4
	The project completed on budget.	2
	The project completed over budget.	2
Quality	No quality error/rework	7
	Minor quality error/rework	1
	Major quality error/rework	0

Safety	Accident free	3
	Minor accident(s)	5
	Major/fatal accident(s)	0
Energy consumption in the use phase	Less than target	0
	According to the target	7
	Higher than target	1

Partnering projects

Among the reported projects by the survey respondents, there were four partnering projects. As can be seen in the following, Table 7 shows the performance of those partnering projects in terms of time, cost, quality, safety, and the energy consumption (in the use phase).

Table 7. Performance of completed partnering projects in Finland and abroad in terms of time, cost, quality, safety and energy consumption in the use phase

Performance of completed partnering projects in Finland and abroad			
Total number of partnering projects reported in Finland		4	
Total number of partnering projects reported in abroad		1	
Performance category	Criteria	Finland	Abroad
		Total number of projects meeting the criteria	Total number of projects meeting the criteria
Time	The project completed ahead of schedule.	0	0
	The project completed on time.	2	1
	The project completed with delay.	2	0
Cost	The project completed under budget.	1	0
	The project completed on budget.	2	1
	The project completed over budget.	1	0
Quality	No quality error/rework	4	0
	Minor quality error/rework	0	1
	Major quality error/rework	0	0
Safety	Accident free	1	1
	Minor accident(s)	3	0
	Major/fatal accident(s)	0	0
Energy consumption in the use phase	Less than target	4	0
	According to the target	0	1
	Higher than target	0	0

IPD projects

There were four IPD projects among the reported projects by the survey respondents. As can be seen in the following, Table 8 shows the performance of those IPD projects in terms of time, cost, quality, safety, and the energy consumption (in the use phase).

Table 8. Performance of completed IPD project in Finland and abroad in terms of time, cost, quality, safety and energy consumption in the use phase

Performance of completed IPD projects in Finland and abroad			
Total number of IPD projects reported in Finland		1	
Total number of IPD projects reported in abroad		3	
Performance category	Criteria	Finland Total number of projects meeting the criteria	Abroad Total number of projects meeting the criteria
Time	The project completed ahead of schedule.	0	0
	The project completed on time.	1	3
	The project completed with delay.	0	0
Cost	The project completed under budget.	0	1
	The project completed on budget.	0	2
	The project completed over budget.	1	0
Quality	No quality error/rework	0	1
	Minor quality error/rework	1	2
	Major quality error/rework	0	0
Safety	Accident free	0	1
	Minor accident(s)	1	2
	Major/fatal accident(s)	0	0
Energy consumption in the use phase	Less than target	0	1
	According to the target	1	2
	Higher than target	0	0

Performance of completed construction projects with the traditional delivery models

CM projects

There were five CM projects among the reported projects by the survey respondents. As can be seen in the following, Table 9 shows the performance of those CM projects in terms of time, cost, quality, safety, and the energy consumption (in the use phase).

Table 9. Performance of completed CM projects in Finland and abroad in terms of time, cost, quality, safety and energy consumption in the use phase

Performance of completed CM projects in Finland and abroad			
Total number of CM projects reported in Finland		2	
Total number of CM projects reported in abroad		3	
Performance category	Criteria	Finland Number of projects meeting the criteria	Abroad Number of projects meeting the criteria
Time	The project completed ahead of schedule.	-	-
	The project completed on time.	1	1
	The project completed with delay.	1	2
Cost	The project completed under budget.	1	1
	The project completed on budget.	1	-
	The project completed over budget.	-	2
Quality	No quality error/rework	2	2
	Minor quality error/rework	-	1
	Major quality error/rework	-	-
Safety	Accident free	-	1
	Minor accident(s)	2	2
	Major/fatal accident(s)	-	-
Energy consumption in the use phase	Less than target	-	1
	According to the target	2	1
	Higher than target	-	1

EPC projects

In total, there were four EPC projects among the reported projects by the survey respondents. As can be seen in the following, Table 10 shows the performance of those EPC projects in terms of time, cost, quality, safety, and the energy consumption (in the use phase).

Table 10. Performance of completed EPC projects abroad in terms of time, cost, quality, safety and energy consumption in the use phase (No EPC project reported by survey respondents in Finland)

Performance of completed EPC projects in Finland and abroad			
Total number of EPC projects reported in Finland		0	
Total number of EPC projects reported in abroad		4	
Performance category	Criteria	Finland Number of projects meeting the criteria	Abroad Number of projects meeting the criteria
Time	The project completed ahead of schedule.	-	-
	The project completed on time.	-	2
	The project completed with delay.	-	2
Cost	The project completed under budget.	-	1

	The project completed on budget.	-	2
	The project completed over budget.	-	1
Quality	No quality error/rework	-	3
	Minor quality error/rework	-	1
	Major quality error/rework	-	-
Safety	Accident free	-	4
	Minor accident(s)	-	-
	Major/fatal accident(s)	-	-
Energy consumption in the use phase	Less than target	-	0
	According to the target	-	3
	Higher than target	-	1

Design-Build projects

There were four DB projects among the reported projects by the survey respondents. As can be seen in the following, Table 11 shows the performance of those DB projects in terms of time, cost, quality, safety, and the energy consumption (in the use phase).

Table 11. Performance of completed DB projects abroad in terms of time, cost, quality, safety and energy consumption in the use phase (No DB project reported by survey respondents in Finland)

Performance of completed DB projects in Finland and abroad			
Total number of DB projects reported in Finland		0	
Total number of DB projects reported in abroad		4	
Performance category	Criteria	Finland Number of projects meeting the criteria	Abroad Number of projects meeting the criteria
Time	The project completed ahead of schedule.	-	-
	The project completed on time.	-	1
	The project completed with delay.	-	3
Cost	The project completed under budget.	-	1
	The project completed on budget.	-	2
	The project completed over budget.	-	1
Quality	No quality error/rework	-	2
	Minor quality error/rework	-	2
	Major quality error/rework	-	-
Safety	Accident free	-	3
	Minor accident(s)	-	1
	Major/fatal accident(s)	-	-
Energy consumption in the use phase	Less than target	-	-
	According to the target	-	2
	Higher than target	-	2

Design-Bid-Build projects

There were 4 DBB projects among the reported projects by the survey respondents. As can be seen in the following, Table 12 shows the performance of those DBB projects in terms of time, cost, quality, safety, and the energy consumption (in the use phase).

Table 12. Performance of completed DBB projects abroad in terms of time, cost, quality, safety, and energy consumption in the use phase (No DB project reported by survey respondents in Finland)

Performance of completed DBB projects in Finland and abroad			
Total number of DBB projects reported in Finland		0	
Total number of DBB projects reported in abroad		4	
Performance category	Criteria	Finland Number of projects meeting the criteria	Abroad Number of projects meeting the criteria
Time	The project completed ahead of schedule.	-	-
	The project completed on time.	-	1
	The project completed with delay.	-	3
Cost	The project completed under budget.	-	1
	The project completed on budget.	-	2
	The project completed over budget.	-	1
Quality	No quality error/rework	-	1
	Minor quality error/rework	-	2
	Major quality error/rework	-	1
Safety	Accident free	-	3
	Minor accident(s)	-	1
	Major/fatal accident(s)	-	-
Energy consumption in the use phase	Less than target	-	-
	According to the target	-	2
	Higher than target	-	2

Difference between the productivity and environmental sustainability of completed construction projects with collaborative and traditional delivery models

The presented information in Table 6 – 12 provided a basis for merging them in two separate figures (7 & 8) in order to compare the performance of collaborative and traditional construction projects in the holistic view. In addition, Figure 7 and 8 provides sufficient details regarding the performance of different delivery models under the categories of collaborative and traditional.

Performance Evaluation of Construction Projects with Collaborative Delivery Models

Performance criteria	Alliance Projects								Average score for alliance projects	Partnering Projects					Average score for Partnering projects	IPD Projects				Average score for IPD projects	Average score for all collaborative projects
	Finland									Finland				Norway		Finland	Bahrain	Turkiye	Canada		
	Office building	Office building	Hospital	Sport facility	School building	Hospital	Office building	Hospital		School building	Office building	Office building	School building	Sport facility		Sport facility	Residential building	Shopping mall	School Building		
	Score (1 – 3)	Score (1 – 3)	Score (1 – 3)	Score (1 – 3)	Score (1 – 3)	Score (1 – 3)	Score (1 – 3)	Score (1 – 3)		Score (1 – 3)	Score (1 – 3)	Score (1 – 3)	Score (1 – 3)	Score (1 – 3)		Score (1 – 3)	Score (1 – 3)	Score (1 – 3)	Score (1 – 3)		
Time	3	3	3	2	2	2	1	1	**2.125**	2	2	1	1	3	**1.80**	2	2	2	2	**2.00**	**2.00**
Cost	3	3	3	3	2	2	1	1	**2.25**	3	2	2	1	3	**2.20**	1	3	2	2	**2.00**	**2.18**
Quality	3	3	3	3	3	3	3	2	**2.88**	3	3	3	3	1	**2.60**	3	2	2	2	**2.25**	**2.65**
Safety	3	3	3	2	2	2	2	2	**2.38**	3	2	2	2	3	**2.40**	2	3	2	2	**2.25**	**2.35**
Average score of four metrics per project	3	3	3	2.5	2.25	2.25	1.75	1.5	**2.41**	2.75	2.25	2	1.75	2.5	**2.25**	2	2.5	2	2	**2.13**	**2.29**
Energy consumption in the use phase	2	2	2	2	2	2	2	1	**1.88**	2	2	2	2	1	**1.80**	2	2	2	3	**2.25**	**1.83**

Scoring system legend

Criteria	Description	Score
Time	The project completed ahead of schedule.	3
	The project completed on time.	2
	The project completed with delay.	1
Cost	The project completed under budget.	3
	The project completed on budget.	2
	The project completed over budget.	1
Quality	No quality error/rework	3
	Minor quality error/rework	2
	Major quality error/rework	1
Safety	Accident free	3
	Minor accident(s) and minor injuries	2
	Major/fatal accident(s)	1
Energy consumption in the use phase	Less than target	3
	According to the target	2
	More than target	1

Average score legend

Average score	Meaning
2 - 3	The performance Exceeds the target.
1 - 1.99	The performance Meets the target.
0 - 0.99	The performance Does Not Meet the target.

Further info

The reported project with LPD model by one of the survey respondents was excluded from this evaluation due to the missing information on the performance of the project in terms of cost, safety and energy consumption in the use phase.

Figure 7. Performance of Construction Projects with Collaborative Delivery Models

Confidential

Performance Evaluation of Construction Projects with Traditional Delivery Models

Performance criteria	CM Projects					Average score for CM projects	DBB Projects		Average score for DBB projects	DB Projects				Average score for DB projects	EPC Projects				Average score for EPC projects	Average score for all tradtional projects
	Finland	Finland	Bahrain	Iran	US		Canada	Bahrain		UK	Turkiye	Norway	Australia		Bahrain	Bahrain	Bahrain	Bahrain		
	Office building	Residential building	Residential building	Residential building	Office building		School building	Office Building		Office Building	Residential building	Hospital building	Residential building		Office Building	Residential Building	Office Building	Office Building		
	Score (1 – 3)	Score (1 – 3)	Score (1 – 3)	Score (1 – 3)	Score (1 – 3)		Score (1 – 3)	Score (1 – 3)		Score (1 – 3)	Score (1 – 3)	Score (1 – 3)	Score (1 – 3)		Score (1 – 3)	Score (1 – 3)	Score (1 – 3)	Score (1 – 3)		
Time	1	2	1	1	2	**1.40**	1	1	**1**	2	1	1	1	**1.25**	2	1	2	1	**1.5**	**1.33**
Cost	3	2	1	1	3	**2.00**	1	1	**1**	3	1	2	2	**2**	2	1	2	3	**2**	**1.87**
Quality	3	3	2	3	3	**2.80**	3	3	**3**	3	2	2	3	**2.5**	3	3	3	2	**2.75**	**2.73**
Safety	2	2	2	2	3	**2.20**	2	3	**2.5**	3	2	3	3	**2.75**	3	3	3	3	**3**	**2.60**
Average score of four metrics per project	2.25	2.25	1.50	1.75	2.75	**2.10**	1.75	2	**1.875**	2.75	1.5	2	2.25	**2.125**	2.5	2	2.5	2.25	**2.3125**	**2.13**
Energy consumption in the use phase	2	2	2	3	1	**2.00**	1	1	**1**	2	1	1	2	**1.5**	2	1	2	2	**1.75**	**1.56**

Scoring system legend

Criteria	Description	Score
Time	The project completed ahead of schedule.	3
	The project completed on time.	2
	The project completed with delay.	1
Cost	The project completed under budget.	3
	The project completed on budget.	2
	The project completed over budget.	1
Quality	No quality error/rework	3
	Minor quality error/rework	2
	Major quality error/rework	1
Safety	Accident free	3
	Minor accident(s) and minor injuries	2
	Major/fatal accident(s)	1
Energy consumption in the use phase	Less than target	3
	According to the target	2
	More than target	1

Average score legend

Average score	Meaning
2 - 3	The performance Exceeds the target.
1 - 1.99	The performance Meets the target.
0 - 0.99	The performance Does Not Meet the target.

Further info

Figure 8. Performance of Construction Projects with Traditional Delivery Models

Conclusions

This study aimed to explore the characteristics and enablers of deep collaboration in construction and to investigate the performance of completed construction projects with traditional and collaborative delivery models in terms of time, cost, quality, safety, and energy consumption (in the use phase). The obtained results provided a basis for the following conclusions:

- The identified characteristics of deep collaboration seem to be routed in project team's behavioral competencies, contract type, and the project's governance style as well as structure.
- Regarding the performance results, it seems that construction projects with both traditional (except Design-Bid-Build) and collaborative delivery models have the capacity and capability to meet their basic targets in terms of time, cost, quality, safety within the project life cycle, and the energy consumption in the use phase of the constructed building/facility. There are, however, some factors like the complexity of the project and competence of the project team which can greatly affect that capacity and capability.
- To be more specific:
    - In terms of project's time and cost performance and constructed building's energy consumption in the use phase, collaborative construction projects seem to outperform the traditional ones.
    - In terms of quality and safety, however, the average performance of addressed traditional construction projects (owing to CM, DB, and EPC) in this study seems to be slightly better than collaborative ones.
- Among addressed collaborative projects,
    - alliance projects seem to have better performance results in the categories of time, cost, quality, and safety compared to IPD and partnering projects, respectively.
    - however, in terms of the energy consumption in the use phase, IPD projects seem to outperform alliance and partnering projects.

Although the findings provide a substantial contribution to the field of collaborative and traditional construction project delivery, it is necessary to acknowledge that these conclusions are based on a relatively small sample of collaborative and traditional projects, addressed in this study. Therefore, further research on a broader scale with a bigger sample size is strongly recommended to get more in-depth insights regarding the performance of collaborative and traditional construction projects.

Research output

The following articles have been written based on the conducted study and submitted to very well-known and top-quality journals:

- Published
    - Moradi, S.; Klakegg O. J. (2024). Conceptualization of collaboration, cooperation, and coordination in construction projects. *In IOP Conference Series: Earth and Environmental Science, vol. 1389, no. 1, p. 012021*. IOP Publishing, 2024. http://dx.doi.org/10.1088/1755-1315/1389/1/012021

- To be submitted:
  - Moradi, S.; Sormunen, P. (2024). Deep Collaboration and Mutual Trust in Construction Projects: Views of Nordic Project Professionals. *Building Research and Information (planned submission date: 10 October 2024).*
  - Moradi, S.; Sormunen, P. (2024). A Comparative Study on the Performance of Collaborative and Traditional Construction Projects in terms of Time, Cost, Quality, Safety and the Energy Consumption in the Use Phase. *World Building Congress 2025 (planned submission date: 15 November 2024).*

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Appendix A. Web-based questionnaire

Investigating and comparing impact of collaborative and traditional delivery models on the performance of building construction projects and environmental sustainability of the constructed buildings

This study, which is conducted at Tampere University in Finland, **aims to investigate and compare the impact of collaborative (e.g., alliance and partnering) and traditional (e.g., design-bid-build) delivery models on the performance (i.e., time, cost, quality & safety) of building construction projects and environmental sustainability of the constructed buildings.**

Answering all the questions in this survey will take <u>maximum 5 minutes of your time</u>, but your responses will provide us with invaluable data through which we will be able to realize the objectives of this research study and contribute toward sustainability in building construction.

There are 19 questions in this survey.

Demographic questions

Where is your country of residence? *

Please write your answer here:

What is your age? *

❗ Only numbers may be entered in this field.

Please write your answer here:

This is a question help text.

What is the highest degree of education you received? *

Choose one of the following answers

Please choose **only one** of the following:

- ◯ Bachelor's degree or equivalent
- ◯ Master's degree or equivalent
- ◯ Doctoral degree or equivalent

What is your gender? *

Choose one of the following answers

Please choose **only one** of the following:

- ◯ Female
- ◯ Male
- ◯ Other

How many years of experience in the construction sector do you have? *

Only numbers may be entered in this field.

Please write your answer here:

____

Please provide us with your you email address if you are interested in receiving findings of this study.

Please write your answer here:

____

Main questions

What was the **type** of your latest building construction project (any of them) which completed at least two years ago? (If you were involved in more than one project at the same time, you may choose the one about which you have the most information. Then, you need to use that information to answer this and the following questions). *

Please choose **only one** of the following:

- ◯ Residential building
- ◯ Office buildling
- ◯ Shopping mall
- ◯ School/University building
- ◯ Hospital building
- ◯ Gym/sport facility
- ◯ Public library building
- ◯ Health and wellbeing center

What was the **<u>delivery model</u>** of your latest building construction project? *

Please choose **only one** of the following:

- ◯ Alliance
- ◯ Partnering
- ◯ IPD (integrated project delivery)
- ◯ Lean project delivery (LPD)
- ◯ Design-bid-build
- ◯ Design-build
- ◯ EPC (engineering, procurement, construction)
- ◯ Construction management (CM)
- ◯ Construction management (CM) at risk
- ◯ Public-private partnership
- ◯ Joint venture

What was the <u>planned</u> **<u>duration</u>** for the project? (Please give your answer by typing the number of years. You may write the approximate amount if you don't remember the exact one. If you don't have sufficient information about the planned duration for the project, you may skip this question.)

Please write your answer here:

What was the amount of planned **budget** for the project? (please write the amount of the budget for design and construction work only in € or $. You may write the approximate amount if you don't remember the exact one. If you don't have sufficient information about the planned budget for the project, you may skip this question.)

Please write your answer here:

Please choose the best statement which applies to the time performance of the project? *

Please choose **only one** of the following:

- ◯ The project completed on time.
- ◯ The project completed ahead of schedule.
- ◯ The project completed with delay.
- ◯ I don't have information.

Please choose the best The project completed on applies to the cost performance of the project? *

Please choose **only one** of the following:

- ◯ The project completed on budget.
- ◯ The project completed under budget.
- ◯ The project completed over budget.
- ◯ I don't have information.

Did the project, upon completion, meet its quality requirements and successfully pass the quality inspections? *

Please choose **only one** of the following:

- ◯ Yes.
- ◯ To some extent.
- ◯ Hardly.
- ◯ Not at all.
- ◯ I don't have information.

Was/were there any <u>major</u> quality error(s) and rework(s) in the execution phase of the project? (if your answer is Yes, then please mention the major quality error/rework in the comment box). *

Please choose **only one** of the following:

- ◯ Yes
- ◯ No
- ◯ I don't have information.

Make a comment on your choice here:

Did the project complete accident-free? *

Please choose **only one** of the following:

- ◯ Yes.
- ◯ No, there were limited number of minor accidents which resulted in minor injuries
- ◯ No, there were several accidents which resulted in minor and major injuries
- ◯ No, there was at least one major accident because of which someone died.
- ◯ I don't have information.

Has the constructed building met the energy consumption target in its use phase? *

Please choose **only one** of the following:

- ◯ The actual energy consumption of the constructed building in its use phase is higher (i.e., worse) than the target.
- ◯ The actual energy consumption of the constructed building in its use is the same as the target.
- ◯ The actual energy consumption of the constructed building in its use phase is less (i.e., better) than the target.
- ◯ There was no energy consumption target.
- ◯ I don't have information.

Has the constructed building met the emission target in its use phase? *

Please choose **only one** of the following:

- ◯ The constructed building's actual emission in its use phase is higher (i.e., worse) than the target.
- ◯ The constructed building's actual emission in its use phase is the same as the target.
- ◯ The constructed building's actual emission in its use phase is less (i.e., better) than the target.
- ◯ There was no emission target.
- ◯ I don't have information.

Please write in your answer the **target** and **actual energy consumption** of the constructed building in your latest project (you may answer this question if you have the required information. Otherwise, you may skip this question).

Please write your answer here:

Please write in your answer the **target** and **actual emission** of the constructed building in your latest project (you may answer this question if you have the required information. Otherwise, you may skip this question).

Please write your answer here:

Thank you very much for your participation in this survey, Should you have any question or comment about this survey, please do not hesitate to contact the leading researcher Dr. Sina Moradi (sina.moradi@tuni.fi).

07-15-2024 – 23:59

Submit your survey.

Thank you for completing this survey.