

Advanced Design Management as Part of Construction Management (CM)

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Abstract

Construction management (CM) contracts are increasingly used in large building projects in Finland. It is understandable that opinions on the relevance of CM forms of contracts vary widely. Finnish owners have had mainly positive but also some negative experiences with their CM projects. Typically, many owners are starting their building investments before users are known or users are not yet ready to determine their design requirements. CM contracts make it possible to start new buildings before even room layouts are designed. It has not been easy to change the traditional culture of the sequential design and construction to the concurrent CM culture. The greatest problems lie inherent in the delivery and the contents of the building design documents. The suggested design management model (FINSuke) enables true teamwork between project actors. The results of the initial tests suggest that there are many advantages in CM projects compared to fixed-price projects. For example, it is possible to arrange enough time for designers in the working drawing phase. Designers may now protect the visual and technical solutions without drawing and specifying all the details before the tendering of subcontracts. In addition, it is possible to utilize the solutions of product suppliers. Final designs can be developed in cooperation among a CM manager, designers, and suppliers before the assignment of subcontract agreements. The best performing contractor (or supplier) is then chosen in competitive terms.

Keywords: Buildings, construction management, design management, Finland, project delivery methods

1. Introduction

Herein, a new model (FinSUKKE) for managing building design processes as part of construction management (CM) projects is introduced briefly. The FinSUKKE model is being developed within the unit of Construction Economics and Management (TKK/CEM) at the Helsinki University of Technology. The FinSUKKE study as a whole aims at developing **a new design management system** which will in part ensure the attainment of the project-specific (or building-specific) objectives in terms of performance, quality, costs, and schedule. In part, a few existing concepts

such as the basic principles of open building [e.g. 1, 2] have been applied to this model design task.

The design management is herein approached in terms of **planning and controlling** the delivery of the design documents and the procurement concurrently as follows. In general, the two kinds of problems beset conventional engineering, i.e. weak process and weak co-operation [3, 4]. The separation of design and construction has long been presented as **the root problem of construction**. This separation threatens, in particular, the constructability of the building in question. Thus, it is no wonder that great expectations have been attached to the use of design-build contracts, where these two stages are integrated at the outset [3]. However, many empirical findings [5,6] have revealed that the design-build contract alone does not produce significantly better results than conventional procurement methods.

In the manufacturing management literature, push and pull are distinguished as the two primary techniques for managing work flows [7,8]. When the pull technique is used, a site will “shout for” design documents from designers. When the push technique is used, design documents are prepared and submitted to a site according to a design schedule. Herein, experiences have proved that no single model functions well alone. For example, a design schedule cannot be effectively derived from a procurement schedule. This is due to a fact that each of separate bidding packages is only a small, “wrong” piece from the point of view of the design process. In the FinSUKÉ model, the design management is perceived as **a combination of a push technique and a pull technique** (Figure 1). From the beginning, design management is a push technique until the inspections of the advancement of the design package take place. After each inspection, the remaining management of the work drawings and the specifications is a pull technique which utilized by management at a site.

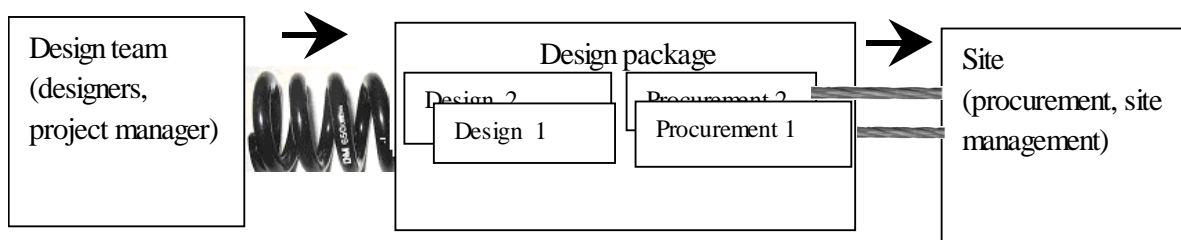


Figure 1: Building design management as a combination of the push and pull techniques.

In many countries, the dominant project delivery methods involve the ones where all the design documents are ready before construction works actually begin. Typically, these practices have been justified by such reasons as pre-managing the complete design process efficiently. On the contrary, the authors counter-argue herein that **the dependencies caused by contract forms and building design must be cut off**. Under CM contracts, the dependencies caused by the contract form are being readily eliminated. But a CM form as a delivery method does not alone guarantee flexible projects. The flexibility has to be carried into subcontracts, especially into building services (M&E) contracts.

From the design management view, **the principles of open building** offer one plausible way to produce highly flexible building (sub)solutions [1, 2]. The cutting of the dependencies not only enables the shortening of the total implementation period, but it has many other advantages. A design team is guided to approach the design of a permanent support with a long life span in a way that differs from the one adopted for the design of an infill part with a short life span. Flexible designs and technical solutions are being enhanced. The principle of cutting dependencies makes also the work of a structural engineer easier because the information such as the loads of the structures and the flues for building services (M&E) are produced on time.

The paper is structured as follows. Next, the founding differences in the use of the contract forms are emphasized in the case of Finland, the UK, and the USA. Thereafter, the three alternative process models of a CM project are introduced. The concept of design packages is introduced as the core of the advanced design management under CM projects.

2. Use of Contract Forms in Finland, the UK, and the US

In Finland, building projects have traditionally been executed under so called **main contract forms**, i.e. general lump sum contracts. A project can be delivered under one main general contract or multiple prime contracts for structural works as well as air conditioning, piping, electrical, automation, and IT installations. When **multiple prime contracts** are used, all the contracts are assigned to the main contractor for coordination only. It is much like the UK nomination system. In Finland, it is normal for owners to hire a professional construction manager (an agent or a representative), who will manage both the design process and the prime contracts. Thus, these main contracts with multiple assigned prime contracts are not considered to be a CM form of contract. In the USA and the UK, construction management with a single general contractor is one of CM forms [9]

In forms of general contracts or main contracts, owners (clients) receive fixed prices and schedules. However, their possibilities to influence processes or to make changes during construction stages are limited. Any change in design involves negotiations between a client and a contractor concerning costs and scheduling. The implied lack of competition infers that changes in the late stages can become expensive.

Chains of competition can be compared in the various forms of contracts as illustrated in Figure 2. In lump sum general contracts, chains of competition are very long. Each building-product purchase must pass 3-4 price competitions. It is very difficult to produce high quality through these kinds of elimination processes. An owner has his or her designers finalize the plans, drawings, and specifications that are used as a basis for arranging competitive bidding among interested general contractors. In turn, a general contractor arranges competitive bidding among second-tier subcontractors, and so on. All these competition stages are based on the cheapest products that meet an owner's requirements. Designers try to avoid a decrease in quality in these competition chains by specifying increasingly detailed product requirements.

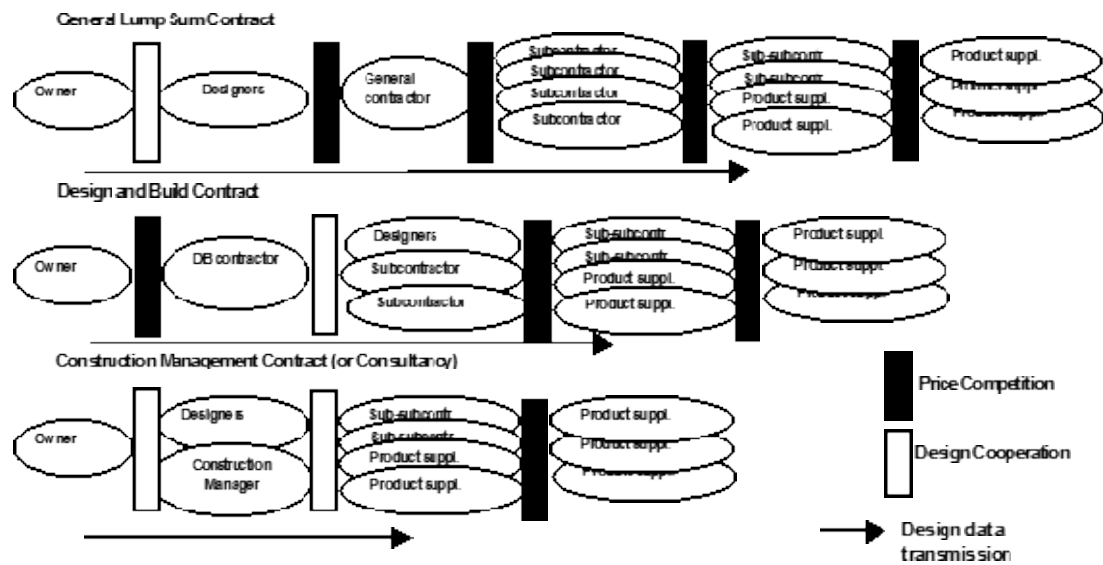


Figure 2: Chains of competition. A comparison of cooperation and price competition in general, design build, and CM forms of contracts [applying 10,11]

Thus, the number of eligible products is reduced and quality/price competition is restricted. All available suitable products and high operational performance cannot be obtained through this low bid chain. Instead, owners are left with many severe low bid problems such as weak quality, chained price competition, decisions made prematurely, and low flexibility for possible design changes [10, 12] When one of the CM forms of contracts is adopted, the improved performance can be part of the selection procedures. In addition, the freedom of suppliers to offer their solutions and assume the responsibility for same can be incorporated into contracts.

The Finnish forms of CM consist of two models as is the case in the USA and the UK, namely, CM consulting (Agency CM or CM for fee) and CM contracting (CM at risk). Construction management is characterized as a form where a professional CM organization leads a project in close cooperation with an owner (client). A construction manager suggests the schedules of the design development packages and those of the procurement packages as well as the related contracts. The relationship between an owner and a construction manager is based on **true cooperation** including open books (cost information). A construction manager acts as an owner's right hand, i.e. their representative who sits at the same side of the table. An owner has the final decision-making power during the course of a project concerning design solutions, trades or works contracts, and suppliers. An owner may make decisions later at more suitable points in time.

The suggested FinSuke model of design management can be incorporated both into a CM consulting form and a CM contracting form. Likewise, many of its principles are readily applicable to design management contexts where other project delivery methods are used.

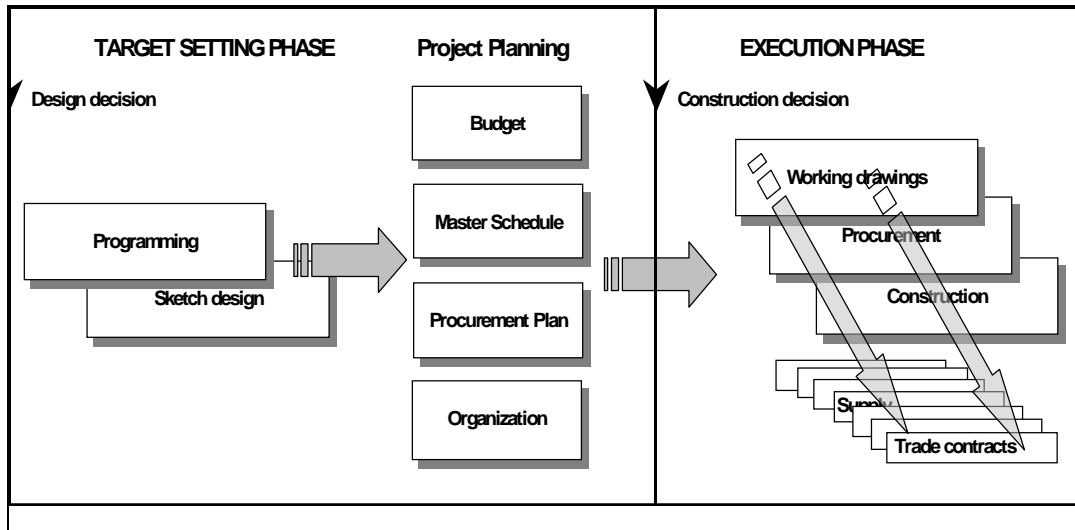


Figure 3: Two-phase model of a construction management (CM) project [12]

3. Three Basic Process Models of a CM Project

In general, a project process is defined to include building design, procurement, and construction works as well as to expose the overlapping of these phases. Herein, **the three alternative basic models** of a project process are illustrated in Figure 4. The critical paths are marked with the shadowed lines. The same (maximum) period of time can be allocated for the actual construction works. **The chain model** is underlying the traditional main contracts, i.e. each sub-process follows fully one another. **The concurrent CM model** involves the time compression based on the two start-ups with the shortest periods that are interrelated, i.e. (a) “Scaling WD1”, which is a period needed to make design documents before the first related procurement, and (b) “Scaling P1”, which is a period needed to make the first procurement before the related building work starts at the site.

The Finnish CM model is designed as a concurrent model, in which the building design, the procurement, and the construction works overlap and particular bidding packages are used as the tools for project management. The durations for making the last working drawings are fairly open to the end.

A physical segmentation adds value also in CM-projects. Using the segmentation it is possible to make design documents ready for one segment while the design of other blocks continues. A segment is usually a vertically sliced entity from a cellar to a roof in new buildings. In addition, the horizontal dimension is applicable in many renovation projects.

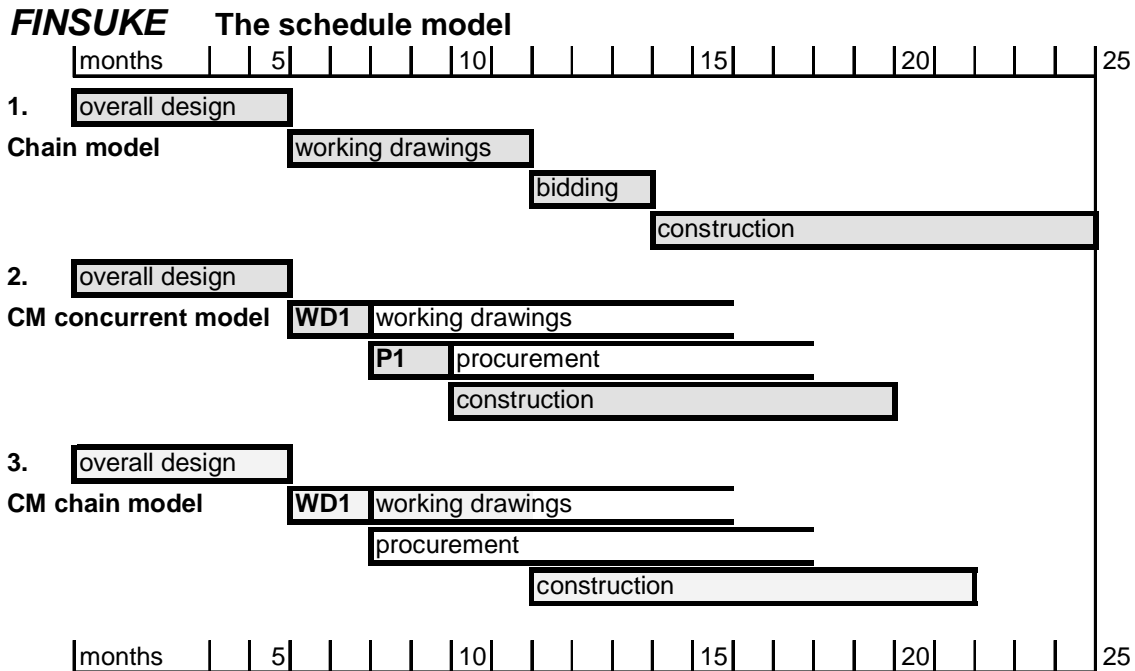


Figure 4: Three alternative project process models illustrated in the case of a typical new building (of 50 000 sqf) in Finland.

4. Design Packages as the Core of FinSUKE model

Under traditional main contract forms, the working drawing phase is often scheduled as one long task (line). Under CM contract forms, the design development is traditionally divided and scheduled based on the project breakdown as **a set of procurement packages**. However, procurement packages are mainly based on trades and so a single procurement package is seldom the most relevant criterion for managing a building design process effectively. Sub-design objects are mostly building elements. Thus, most procurement packages do not contain the complete sets of the enabling sub-designs. This fragmentation of design work causes problems for the delivery of design documents. For example, when only one set of design documents for a procurement package is suddenly needed, the designer must ad hoc solve the related design package as a whole. In the same vein, when the building works are compiled into packages purely by trades, this implies the fixing of many preceding sub-designs too early (concerning e.g. metal works, masonry works).

When the design management is acknowledged as one of the primary, interrelated processes, separate design tasks and documents are compiled into sub-designs based on the concentrations of the primary dependencies among the design tasks themselves. In the suggested FinSUKE model, these sub-designs are managed and called as **design packages**. The model includes a list of standardized design packages with their basic contents.

Table 1. @b@1@e@1 FinSUKE standard design packages, building services (M&E) is not included. Based on Finnish Building 2000 BE classification (translated using UNIFORMAT II) @b@6pr

Design package		Design package	
0	The supplementing design documents	8	Space partitions and doors
1	Excavation works	9	Spacial components
2	Demolition works	10	Other space structures
3	Foundations and slab on grade	11	Interior finishes
4	Elevetors	12	Fittings (to be removed)
5	Frame	13	Fittings (new)
6	Enclosure	14	Space equipment
7	Roofing	15	Site

In each CM project, **design packages** are determined early as part of a project plan. A CM team compiles and schedules a set of the most effective design packages in cooperation with the designers. The design work is divided on a basis of the standard design packages. Optimally, each project-specific design package includes those parts and works which are procured at the same time and produced accordingly through the preceding design tasks (Figure 5).

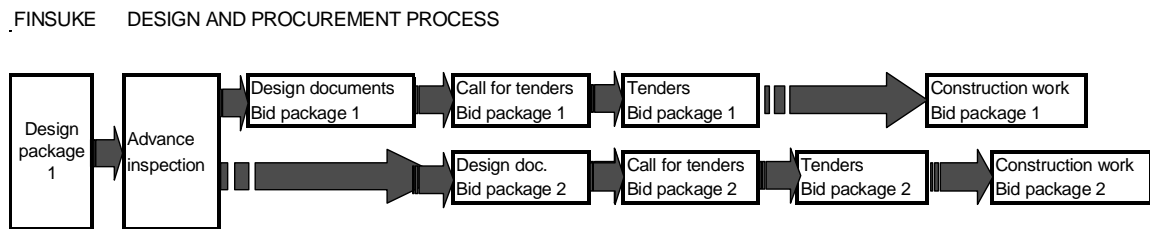


Figure 5. Management of a building design from the design package to its use as a basis for the procurement phase and the construction phase (FinSUKE).

The use of design packages enables **the design team** to achieve many advantages such as:

- To avoid the accumulation of the design work (traditionally scheduled as one task) to the last remaining days through the introduction of design phasing.
- To facilitate effective communication among the designers as well as between the owner and the design team and the procurement team.
- To balance the need and use of design capacity and to enable the flexible increase of the design resources when needed.
- To avoid the preparation of non-constructable sub-designs for single procurement packages.
- To avoid the non-productive preparation of design documents with too small scopes.

- To allow more time, overall, for the attainment of the key objectives of the building design such as functionality, safety, environmental conformance, and aesthetics.

In addition, the use of design packages enables **the procurement team** to achieve several advantages such as:

- To integrate two or more initial design packages to support bigger procurement packages, when this is justified.
- To prepare all the documents of one design package effectively and later to phase the submission of the finished documents according to the related smaller procurement packages.
- To initiate the procurement of a certain package without the need to prepare and submit all the related design documents at the same time.

At the project level, the use of design packages enables **the project management** to achieve the key advantages such as:

- To allow the beginning of the construction work also in the case when all the related design documents are not ready.
- To leave more (enough) time for decision making, especially concerning the final infill of the building.
- To enable the control of the design process and the real-time feedback to the sub-designs.
- To inspect each design package in advance will prevent typical design errors from occurring.

In the FinSUKÉ model, **a design schedule** is prepared by design packages also in the cases when construction works would not begin before the completion of the design

In the design documents (packages), **a breakdown into the procurement packages** need not to be readily presented. In turn, a CM team determines the contents of each procurement package after the completion of the related design packages. A CM team prepares the tender documents where the contents is specified (often in more detail than in the related design documents) for the procurement. However, some of the traditional trade divisions (e.g. the masonry works for the facade/interior and the steel works) needs to be broken down into parts.

In turn, **a procurement schedule** is prepared by using and integrating the design packages (Figure 6). This is so because the common language is needed in order to ensure the seamless interfaces between the site staff and the designers. Thus, both the design documents and the tender documents are assembled by the design packages.

DRAWINGS	DESIGN PACKAGE	BID PACKAGES
Cut-away drawings Details Balcony Windows and outer doors diagrammatic documents	6 THE FASADE Fasades, outer doors, windows Fasade equipments Balcony, canopy	Fasade timber work Fasade claddings Fasade equipments Flashing Windows Outer doors Painting Balconies

Figure 6. Design package as a linkage between design documents and procurement breakdown.

In the FinSUKÉ model, all the design documents are drafted and finalized up to the working drawings that enable the actual procurement. The exceptions are stated in a project plan.

In CM projects, **the completion degrees of design documents for a procurement package** may vary. In each case, the selected procurement strategy determines the required completion degree. Readily, there are (at least) the three alternative procurement strategies as follows:

- Bidding based on working drawings
- Bidding based on tentative design documents
- Bidding based on design requirements.

In the design schedule of a CM project, the allocation of time takes place at a level which allows to present (a) the preparation periods for the design packages, (b) the dates for the pre-inspections of the design packages, (c) the dates for the uses of the design packages, and (d) the dates for the uses of the working drawings for the procurement packages.

5. Conclusions

In traditional building projects in Finland, all the decisions are made in the beginning of the design process. The easy-way-out attempts are being made to fix the final layout of the spaces and to specify the products by dictating these decisions prematurely. After the prolonged project process, the spaces have become readily outdated and, as usual, any changes would turn out to be expensive. Normally, designers specify all building products in detail. When a contractor has been buying these detailed products, the prices have risen to too a high level; while other suppliers offer cheaper products which have same or even better properties.

The suggested FinSUKÉ model is designed in order to change the aforementioned ineffective procedures. The permanent support (shell and core) of the building will be designed first so that it will meet the demands of the modifiable infill. The detailed solutions of the spaces (infill) are

finalized according to the space-specific decisions; taking also into account the choices of the tenants. For a procurement phase, design documents can be prepared well to comply with each of the “chosen” products. During the negotiations, a procurement team (i.e. procurers, project manager, and designers) reviews upon how the alternative solutions influence the final outcome. If the other solution is chosen, the original product will be replaced.

Standard design packages fit the construction of new buildings. Instead, the effective adoption of CM forms is more demanding in the case of renovation projects and in building services (M&E) works. For example, the management of M&E design programs is problematic due to sub-wholes based on each of the spaces (or interior areas).

In the FinSUKKE model, the design management is theoretically defined as **a combination of a push technique and a pull technique**, i.e. as a push technique up to the completion of the design package and, thereafter, as a pull technique performed by the site management. The site team secures the status of the design documents for 4-6 weeks ahead. A tool like The Last Planner [13] seems to be effective for the pull-based control at site. In addition, **the principles of open building and the principal procurement strategies** are being incorporated into the later versions of the FinSUKKE model.

The testing of the design packages and the other FinSUKKE tools will continue up to the year 2006. So far, the parts of the model have been mainly tested retrospectively. The testing of FinSUKKE model prospectively will also be carried out. In particular, the ways of managing building services (M&E) design process need to be enhanced further.

In Finland, **the scope of design work and design management tasks** are described with standard task lists published by the Building Information Foundation RTS [14]. The standard task lists are prepared for the main contract forms. Such task lists do not at all support the active participation of the designers in the procurement process and the construction process. The TKK/CEM research team is preparing the lists of additional tasks as part of the FinSUKKE model.

Finally, the authors do not believe that, in building projects, one can succeed by trying to attain the set objectives by drawing up the more exact descriptions of the tasks of the various project actors and arranging the low-bid competitions for the accomplishment of the detailed tasks. In turn, **the authors recommend performance based methods** for selecting CM consultants, designers, CM contractors, and subcontractors [see 15, 16] .

The suggested FinSUKKE model promotes and creates procedures and methods to improve the cooperation among the parties in the construction project. The essential tool to increase the cooperation is a project plan in which the design packages are integrated. Furthermore, the advance inspections of the design packages and the contract negotiations promote cooperation. The constructability is secured at the negotiations during the selection of subcontractors. It is possible to buy product know-how from the suppliers and it is possible to transfer responsibilities for the products to their actual experts – to subcontractors and suppliers. The best performing

contractor (or supplier) is then chosen. In CM projects, it is possible to have enough time for this cooperative design development during procurement process.

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