Communication Patterns in Construction at Construction Manager Level

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Abstract: The procurement process of construction projects has been affected by developments in the field of Information Technology, as well as by the need to cope with growing technological challenges stemming from the integration of multiple building systems into tall and complex buildings. Furthermore, since the procurement phases are undertaken simultaneously, project complexity is increased, and increased integration among them is therefore required. These constraints have made the management of complex construction projects less of an architectural and engineering issue and more of a managerial one. In turn, this has led to an increasing use of the ''construction management'' concept in the procurement process. This study focused on communications in construction management procurement of building and residential projects in Israel. Communications between the construction manager and the design team were found to be vital in ensuring adherence to project objectives. Communication means were classified as ''formal''—written technical information, and as ''informal''—verbal communications. Construction managers in Israel still use informal communications in 50% of their interactions with their project counterparts. The study concludes that design capabilities should be one of the essential qualifications required of a construction management firm. In addition to the more traditional responsibilities, such as planning, scheduling, and coordination, the scope of the construction manager's professional duties should emphasize the aspect of quality management.

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Introduction

During the last few decades, construction projects have shown a trend towards becoming large complicated operations involving many participants (designers, contractors, subcontractors, suppliers, inspectors, etc.). The construction of large projects involves multiple disciplines and electromechanical systems, which require a high degree of coordination between their participants.

A typical construction project consists of five phases: (1) conceptual planning; (2) design; (3) tendering; (4) construction; and (5) commissioning. The second and third phases have been vastly affected by the development of Information Technology (IT), while the construction phase has not benefited from a similar level of computerization, despite recent advances in IT (Tam 1999).

Rationale of Study

The construction manager is the pivot point of the construction management procurement process. The ever-growing complexity of projects, the increasing demand for fast-track construction, and the overlap between the basic phases of construction projects present the parties involved in them with a challenge of coordination. One of the preferred procurement methods in the fast-track construction environment is construction management procurement. This delivery scheme is characterized by multiple contractual relationships among many of the participants, such as designers, consultants, subcontractors, and so on. The achievement of a project's goals is highly dependent upon the capability of the construction management team to *communicate* effectively with the main parties partaking in the project.

Objectives

The objectives of the study were as follows:
1. To document communication patterns in terms of addressees, means, and topics of communication at the construction manager level. The aim was to identify the principal parties with whom the construction manager interacts, main means of communication, and topics of interaction; and
2. To identify effective patterns of communication at the construction manager level.

Background

Construction projects are always multidisciplinary, often large, and require the participation of many different parties during the course of their execution. These features introduce uncertainty into the typical project. Studies showed that uncertainty increases with the size of the project, and with the number of participants. The size of large projects and the desire to shorten the duration of the delivery process require simultaneous procurement of the project. During certain stages, some phases may very often be undertaken simultaneously, requiring major efforts in terms of the

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coordination and communication between the participants. Thus, uncertainty is a dominant factor in the planning and construction phases (Laufer 1991; Laufer and Howell 1993; Cohenca et al. 1994; Cohenca-Zall 1997). As in other countries, in Israel, too, this has promoted the adoption of construction management procurement in construction projects. The principal person charged with coordination in construction projects delivered through construction management is the construction manager (CM).

Information Technology (IT) affects all aspects of the construction process. Current computing technologies provide construction professionals with access to rapidly evolving communication pathways. This access has profound implications for the construction industry in several areas, such as intraoffice communications, client relations, design coordination, and site management (Chinowski and Meredith 2000). One such implication has been the dramatic change in the communication environment of construction projects, due to the impact of Information Technology and the comprehensive computerization of the design process.

Contractual Arrangements in Construction Projects

Construction and civil engineering projects are exceptionally complex, both in design and in implementation. The increasing complexity of buildings has brought about the development of management techniques in an effort to avoid some of the disruptions that may occur in the traditional contractual arrangement. Three procurement protocols are most frequently used in construction projects.

1. Traditional procurement
   The traditional procurement arrangement involves three main participants: Owner, design team, and general contractor. In this procurement protocol, the owner has a direct contractual relationship with most of the participants. In small simple projects, the traditional arrangement saves management resources. In complex building projects, however, longer procurement times are required and coordination deficiencies are suffered as a result;
2. Design-build contracts
   According to this procurement protocol, the general contractor undertakes full or partial responsibility for the design and construction stages. This contractual arrangement differs from the traditional arrangement in the single line of responsibility that exists between the owner and the contractor. The principal advantages of this procurement scheme, from the owner's point of view, are the elimination of any claims by the contractor due to inadequate design or specifications, and the ability to begin construction of each separate phase of the project as soon as its design is completed, without having to wait for the completion of the overall project design. Fast-track construction was developed within the framework of the design-build procurement method (Fisk 2000); and
3. Construction management
   The increasing complexity of projects has led to the development of the construction management procurement protocol, in which there is no main contractor interposed between the owner and the various specialist subcontractors. The construction manager becomes the principal consultant coordinating the entire procurement process, from the conceptual design through the commissioning of the project. Construction management firms do not perform any design or construction activities of their own, but rather act as the owner's representative, controlling and managing the flow of information during the life cycle of the project.

Professional construction management eliminates some of the risks involved in the fast tracking of traditional contracts. Instead of submitting a bid for 80% of the design of the entire project, a trade contractor will bid on 100% of his or her own share of the design (Rubin and Wordes 1997).

Communications in Construction Management

Communications are, in general, the basic means through which managers interact with the project counterparts (Orlikowski 1994). Previous studies (Parker 1980; Shohet and Laufer 1991) categorized communications in construction projects as (1) formal—using written means (e.g., fax, letters, E-mails, blueprints, and specifications); and (2) informal communications—verbal face-to-face or electronic means. It was shown that the role of informal communications in construction projects is crucial to the effectiveness of construction. In his book, *Simultaneous Management* (Laufer 1997), Laufer recommends the introduction of "an intensive communications system capable of sharing a large volume of information among a large number of people, in a frequent and rapid manner." Laufer's emphasis is on the use of multiple media, including face-to-face communications and electronic communications. Walker (1995) indicated the use of bidirectional communications as a means of improving quality in construction. Rwelamila (1994) emphasized the critical role of the construction manager in communicating with multiple participants in the project. Olson (1982) focused on the effects of poor communications at the management level on productivity at the crew level in construction projects. Jergeas and Hartman (1994) highly recommended keeping good records and communications as a means of avoiding claims and disputes in construction projects. Coble and Snow (1996), as well as Mackanzie et al. (1999) found that communications have a significant effect on the safety records of projects, both in the design and construction phases. All of the above-mentioned studies reflect the principal role of communications in ensuring the effectiveness of construction projects.

Project Effectiveness

Four basic parameters exist, through which the effectiveness of construction projects is measured (Hinze et al. 1981; Levitt and Samelson 1993; Ledbetter 1994; and Walker 1995):

1. Timeliness—adherence to schedule;
2. Productivity—the efficiency of labor;
3. Cost effectiveness—adherence to budget frame; and
4. Safety—This parameter is a measure of the effective performance of construction managers.

The criterion used in this study for the evaluation of project performance is based on a composite index, integrating the aforementioned basic elements, as will be presented hereafter.

Research Methodology

The principal research tools used in the study were structured questionnaires completed during an interview, and a descriptive and comparative statistical analysis (Oglesby et al. 1989). Following is a detailed description of these tools:

1. Structured questionnaires—Project data were gathered by means of structured interviews with construction managers. The questionnaire used by the interviewer addressed the following aspects of the projects:

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- Project characteristics (budget, duration, and organizational scheme),
- Quality of design (suitability for construction, timeliness of design drawings supply, delays in construction due to design drawings delays). These data were studied as independent variables affecting the performance of the construction manager. Quantitative scales reflecting the frequency of required revisions were used for the evaluation of the quality of the design drawings,
- Communications at the construction manager level (means, addressees, and topics of communication),
- Planning (breakdown of planning horizon according to planning topics),
- Project effectiveness (measured in terms of timeliness and budget overruns),
- Safety (in terms of the number of injury accidents), and
- Means of cost control.

2. Descriptive and comparative analysis—Findings were analyzed in two stages: (1) descriptive analysis and (2) comparative analysis. The analysis began with the identification of links between the variables measured in the study. The variables were then tested by means of a comparative analysis in which the sample projects were categorized as ‘‘effective,’’ ‘‘ineffective,’’ or ‘‘noncharacterized.’’ ‘‘Effective’’ projects were defined as projects that receive high composite index scores. This score includes timeliness, cost-effectiveness, safety, productivity, and surveyor evaluation. ‘‘Ineffective’’ projects were defined as projects that demonstrate low adherence to schedules, low cost-effectiveness, and poor safety records. ‘‘Noncharacterized’’ projects are projects that cannot be classified into either of the first two categories. Variables characterizing the construction managers in ‘‘effective’’ and ‘‘ineffective’’ projects were compared, and the significance of trends was examined from a statistical viewpoint, and conclusions and recommendations were drawn.

Findings

The data gathered in this study included some 30 projects, 20 of which were selected on the basis of the qualifying criteria, which included a minimum budget of \$4 million, a minimum floor area of 5,000 sq m. An additional parameter, the actual value-adding rate, was defined as the value of construction per square mile divided by the duration of construction. The projects included in this survey had a minimum value-adding rate of $17.0\,\$/(\text{sq m}\times\text{month})$.

Profile of Projects Included in Survey

The field survey included building and residential construction projects of 3 types: (1) residential buildings—11 projects; (2) office buildings—six projects; and (3) industrial buildings—three projects. All projects were delivered through construction management procurement. Nine of the construction management firms studied were ISO 9002 accredited.

Sample characteristics are summarized in Table 1. Average budget scope was \$18 million, mean labor input was 60,000 working days, and the average construction time was 26.8 months. Ninety percent of the actual value-adding work was carried out by an average of 20 subcontractors per project. The average number of personnel employed by subcontractors was 175. In this survey, the intensity of construction was measured by means of an index that represents labor intensity: Labor input per square meter. The index presents the total man-hours invested in the project per total floor area and is indicative of the overall labor intensity of the project. This index showed a high average of 22.4 h per sq m, reflecting the fact that industrialized construction is performed only in skeleton works, while most finishing activities executed in Israel are still performed manually and are thus quite labor intensive.

Table 1. Sample Characteristics

Variable	Average
Budget (\$ million)	18
Total manpower (working days)	60,000
Duration of construction (months)	26.8
Cost per sq mi (\$/sq m)	722
Number of subcontractors	20
Construction performed by subcontractors (% of total cost)	90
Average number of subcontractor personnel	175
Number of hours per sq m	22.4

Intensity of Construction

The rate of construction was calculated by means of an index termed ‘‘construction intensity,’’ defined as follows:

$$CI = T/(C*A) \tag{1}$$

where CI = construction intensity; C = total cost of construction (\$); T = expected duration of construction (months); and A = total area of construction (sq m).

This index reflects the construction progress of a specific project (conventional building, wooden structures, multisystem structures, etc.). The mean construction intensity for the survey was $29.0\,\$/(\text{sq m}\times\text{month})$ $(SD=9.4)$. Only two projects achieved relatively high intensities that exceeded $40\,\$/(\text{sq m}\times\text{month})$, while the majority of the sample progressed at a slow or moderate intensity. This may be attributed to a lack of coordination between design, planning, and construction phases, as illustrated hereafter.

Design

The principal findings with respect to the design are summarized in Table 2, and may be concluded as follows:

1. Quality of design—Most construction managers perceived the design drawings as imprecise and incompatible with principles of good practice. Forty-five percent of the design drawings in the survey required serious revision, i.e., only 55% of the design drawings were found to be suitable for construction without any revision,

Table 2. Quality of Design Characteristics of Sample

Variable	Average
Quality of blueprints (% of accurate drawings) (structural, architecture sequence of revision)	55
Effect of design changes on construction delays (days/month)	1.9
Timing of supply of original blueprints (days prior to construction)	2
Waiting period for missing blueprints (days)	5.4
Supply of revised blueprints (days prior to construction)	2

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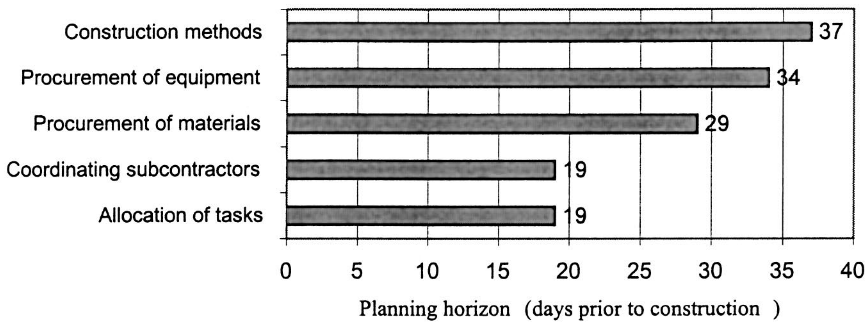

Fig. 1. Average planning horizon (in days), by planning topic

2. The average influence of design changes on a project schedule was 1.9 days per month. This implies that a project that extends over more than 20 months (as did the majority of projects in this sample) was delayed by more than 40 working days due to the high frequency of design revisions. Similar conclusions with regard to design revisions were drawn in a recent analysis of construction delays in Jordan (Al-Momani 2000); and
3. The above-mentioned delays may be attributed to the late supply of original design drawings and of revised design drawings (only two days prior to construction). These values may indicate the existence of faulty communications between the design team and the construction management team and poor coordination between the design efforts and the construction schedule. This situation is revealed in the extended waiting periods for revised drawings experienced by the construction manager—5.4 days behind schedule.

These findings may indicate that time coordination between the design team and the construction management team is one of the crucial elements affecting project efficiency in construction management procurement in Israel. The effect of poor coordination extends far beyond the design process and causes significant delays in the schedule of the entire project, as reflected by the low average of construction intensities (value-adding rate) found in this study.

Safety

The level of safety was evaluated using the number of injury accidents that had occurred at each site prior to the survey visit. Findings indicated poor safety performance in the sample projects. Sixty-five percent of the projects in this sample had experienced at least one injury accident, and the average number of accidents was four. This finding may be attributed to a lack of awareness of safety management at the construction management level, but it might also be due to building regulations that cast the entire responsibility for site safety on the general contractor's superintendent and ignore the role of safety at the engineering and management levels of the project. These regulations were originally formulated to suit the traditional procurement approach, by which the main body of project personnel is employed by the general contractor. However, in construction management delivery, the principal managerial authority is the construction manager, and most of the value-adding work is undertaken by subcontractors.

Planning Horizon

The planning patterns of the construction managers were measured according to their estimated planning horizon, which is defined as the number of days, prior to construction, required by the construction manager for planning measures. The planning topics were categorized as follows:
1. Construction methods;
2. Equipment procurement;
3. Materials procurement;
4. Subcontractors coordination; and
5. Allocation of tasks (to subcontractors).

The results, presented in Fig. 1, show that the planning horizon for the first three categories was 29 days or more, while the last two categories, which focus on the coordination of subcontractors, received less than 20 days for each category. Despite the need for tight coordination of construction crews, the construction managers did not find the expansion of the planning horizon to be effective.

Communication Patterns

Communication patterns at the construction manager level were investigated by subdividing communications into the general categories: means, topics, and addressees of communication. In the following paragraphs, we discuss the findings and conclusions drawn from this analysis.

Means of Communication

The construction manager's communications were divided into three categories (Table 3):
1. Written technical communications—52% (e.g., design drawings, letters, specifications, E-mails);
2. Verbal communications in face-to-face meetings—28%, and

Table 3. Communications Characteristics of Sample

Characteristics	Average (%)
Means of communication	
Written technical communication	52
Verbal communication at meetings	28
Verbal communication by electronic means	20
Total	100
Topics of information	
Construction instructions	30
Materials and equipment	11
Quality management	13
Allocation of manpower	30
Cost control	16
Total	100

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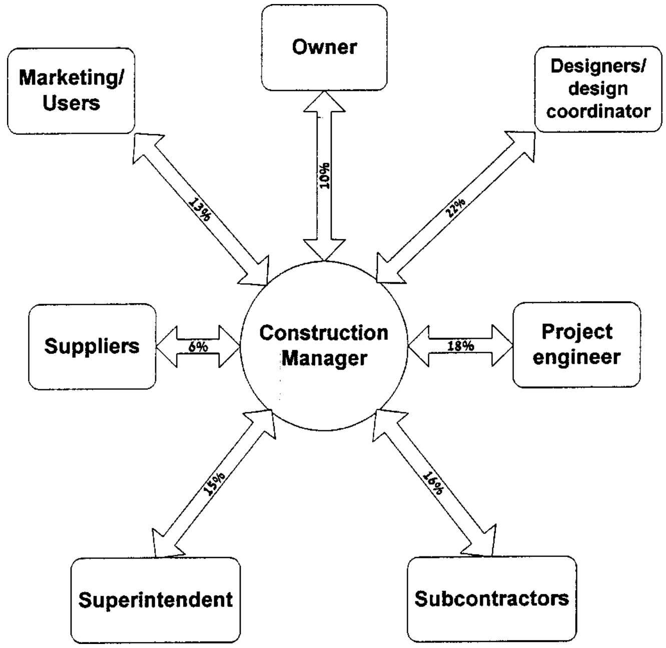

Fig. 2. Distribution of communications between the construction manager and other project participants

3. Verbal communications by electronic means—20% (e.g., teleconferencing, telephone).

Despite the significant use of electronic means, approximately 50% of the communications at the construction manager level were made by informal (verbal) means, while the other half consists of formal printed or electronic communications. The breakdown of communications within the categories showed that the use of E-mails for formal communication is negligible (2%). This characteristic has not changed in the last two decades despite significant advances in IT experienced by construction projects in the area of design.

Topics of Communication

Topics of communication were classified into five categories: (1) instructions; (2) materials and equipment; (3) quality management; (4) allocation of manpower; and (5) cost control. The first two categories, representing technological issues, accounted for 30 and 11% of the total communications, respectively. The third category accounted for 13%, the fourth, allocation of manpower, for 30%, and cost control accounted for 16%. A comparison of the time devoted to each of these topics with the findings pertaining to the planning horizon (Fig. 1), reveals that the planning horizon for the coordination of subcontractors was relatively short (19 days), but that this topic still accounted for almost one third of the construction manager's communications. This may reflect the high intensity required for coordination of subcontractors in the construction management delivery protocol, probably due to the high degree of uncertainty associated with subcontractor availability, and to the high actual value-adding work undertaken by subcontractors.

Communication Addressees

The next criterion examined was the communications addresses of the construction manager. Construction managers were requested to give a breakdown of the communications between the major participants in the project. The distribution is presented in the form of a ''sun-diagram,'' with the construction manager located at the center of interactive communications (Fig. 2). The diagram reveals that the construction manager devotes more than a fifth of his or her communication efforts to the design team, 18% to the construction engineer, 16% to subcontractors, and 15% to the superintendent. The owner and the end-users of the building together account for 23% of the efforts (10 and 13%, respectively).

This distribution of communications may be classified into three principal categories: engineering topics (design team and construction engineer)—40%, coordination, and control (suppliers, superintendent, and subcontractors)—31%, and business issues (owner and/or marketing)—23%. This breakdown of communications shows that the main proportion of the CM's efforts is devoted to managerial tasks. This finding may be attributed to the fact that, in this sample, 90% of the actual value-adding work in a typical project was executed by subcontractors. The division of construction between various subcontractors requires a great deal of attention and a high level of coordination on the part of the CM, in which time is devoted to the management and coordination of subcontractors at the expense of engineering and business topics.

Comparative Analysis of Projects

This part of the study focused on a comparison between projects that were clearly defined as ''effective'' and projects that were identified as ''ineffective,'' based on the composite performance index of each project. The composite index, the classification of ''effective'' and ''ineffective'' projects, and the findings of the comparison between them are presented below.

Composite Project Performance Index

The criterion for the evaluation of project performance was determined by the composition of four parameters: cost-effectiveness, timeliness, quality, and safety. The composite index is composed of 100 points, divided among the following components as follows: (1) delays in construction —25%; (2) project intensity (value-adding rate) —25%; (3) time allocated to planning (by the CM)—15%; (4) CM evaluation of effectiveness—10%; (5) number of accidents involving injury—15%; and (6) surveyor evaluation of the project—10%.

Table 4 presents the composite index components and the ranking scale for each. The surveyor evaluation was carried out using criteria such as site layout, quality of construction, and workmanship. A maximum score of 100 is achieved by projects that experience no delays, no safety incidents, a high construction intensity (value-adding rate), high planning input on the part of the CM, and a high evaluation of the site layout and construction quality (by the surveyor). The mean composite index in the survey was 59.5. The lowest score received by a single project in the survey was 27.5, and the highest was 80.0. The average value reflects a mediocre environment. The average composite index value correlates strongly with the design drawings precision (55%).

''Effective'' and ''Ineffective'' Projects

The composite index enabled classification of the sample into three categories:

1. ''Effective'' projects—Projects that are clearly associated with a relatively high effectiveness. This category included five projects with an average composite index of 76.5;

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Table 4. Components of Project composite Index

Parameter	Weight (%)	Units	Scale and score			
Construction delay	25	Days	0–1	2	3	4+
		Score	2.5	2	1	0
Accident involving lost days	15	Number of accidents	0	1	2	3+
		Score	1.5	1	0.5	0
Intensity of construction	25	\$/(sq m×month)	10–30	31–40	41–50	51+
		Score	0.5	1.5	2.0	2.5
Planning time	15	Time (h)	0	0.5	1	2+
		Score	0	0.5	1	1.5
Evaluation of construction manager	10	1–4	Slow	Faire	Fast	Accelerated
		Score	0	0.25	0.5	1.0
Surveyor evaluation	10	1–4	1	2	3	4
		Score	0	0.25	0.5	1.0

2. "Ineffective" projects—Projects that are clearly associated with poor project effectiveness. This category included four projects with an average composite index of 36.9; and
3. "Noncharacterized" projects—Projects that cannot be classified into either of the aforementioned categories.

The next section presents a comparison between the categories of "effective" and "ineffective" projects, using the parameters and findings presented in the previous section.

Comparison between "Effective" and "Ineffective" Projects

"Effective" and "ineffective" projects were compared using the entire range of variables measured in the survey. The main findings of this comparison were as follows:

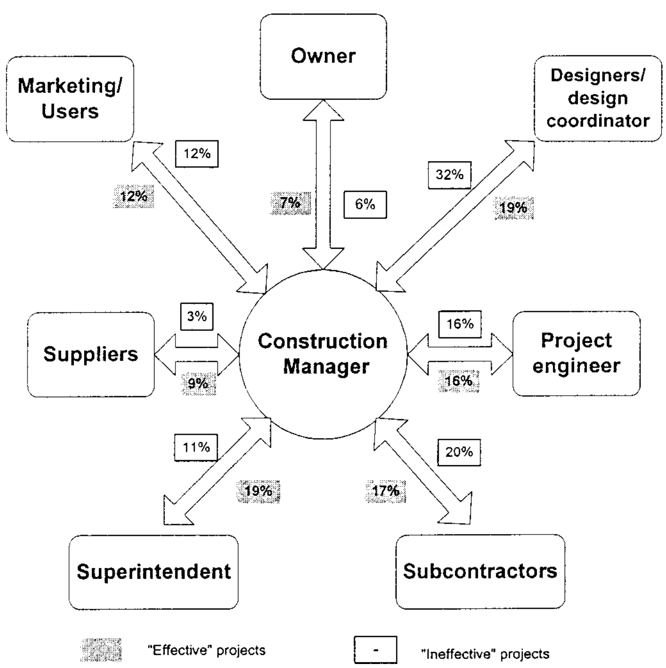

Fig. 3. Distribution of communications between construction manager and other participants—comparison between "effective" and "ineffective" projects

1. Addressees of communications were significantly different (Fig. 3). "Effective" construction managers (CMs) spent much less time interacting with the design team than did "ineffective" CMs (19 versus 32%). The time surplus was utilized by the "effective" construction managers for communications with the superintendent (19 versus 11%), and with suppliers (9 versus 3%). These differences exhibited a statistical t-test significance of $p<0.01$, and may be attributed to the capability of construction managers in "effective" projects to introduce solutions to some design and technological problems. The relatively lower interaction with the design team enabled them to formulate technological solutions in conjunction with the line management and the suppliers. It should be noted that the quality of design as evaluated by "effective" CMs (40%) was far below the quality of design as perceived by "ineffective" CMs (60%). This finding may indicate that the problem-solving treatment exhibited by construction managers is effective in overcoming design difficulties associated with the low quality of design drawings.
   One interesting case was presented by a public building that included a below-grade parking lot with slab and lower beams system. In reviewing the design drawings of the below-grade parking structure, the construction manager noticed that no horizontal installation pathways were incorporated into the lower beams for systems such as fire-protection, communications, and ventilation. The CM requested revisions of the design drawings, but the design team was unable to complete the superposition drawings due to a lack of details regarding the electromechanical systems. The owner insisted that the project remain on schedule, thus requiring the continuation of construction. The CM suggested that "sleeves" for installation pathways be installed in the lower beams prior to casting, to be used later on for fire-protection, ventilation, and communications installations. Eventually, these "pathways" were used as installation pathways, and saved significant time and costs due to changed orders. This example demonstrates the importance of the CM's ability to interpret the design drawings and to introduce creative design solutions in cases where information is lacking;
2. A major difference between the "effective" and the "ineffective" projects was revealed in the delay in schedule dur-

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Table 5. Distribution of Delay Causes—Comparison between "Effective" and "Ineffective" Projects

Delay causes	Delay (days) "Effective"	"Ineffective"
Lack of resources	0.2	2.58
Lack of information	0.27	0.36
Overlap of work crews	0	0.06
Rework (poor quality)	0.04	0.36
Lack of subs coordination	0.07	0.24
Unexpected causes (closure, etc.)	0.11	0.30
Poor constructibility	0.2	1.38
Poor productivity	0.11	0.78
Total	1.00	6.00

ing the last month of construction: one day for "effective" projects compared with six days for "ineffective" projects (Table 5). The average six-day delay in "ineffective" projects was primarily attributed by construction managers to the following causes: (1) lack of resources (materials, equipment, and manpower) −2.6 days/month; (2) technological difficulties (e.g., poor constructibility) −1.4 days; and (3) poor productivity −0.8 days/month. The one-day delay in "effective" projects was attributed to the following: (1) lack of information −0.27 day/month; (2) lack of resources −0.2 day/month; and (3) constructibility problems −0.2 day/month. All of the latter differences between the two project categories were shown to have a significance of $p<0.05$. It is apparent that the majority of delays in both categories are attributed to resources and technological issues, and not to productivity issues;

3. In Table 6, a comparison is presented between topics of information and CM communications in "effective" projects and those of "ineffective" projects. Topics of information and communications were classified into five categories: (1) instructions; (2) materials and equipment; (3) quality management; (4) scheduling and coordination of subcontractors; and (5) cost control. The distribution presented in Table 6 shows that the only significant difference between "effective" and "ineffective" projects was in quality management. Construction managers in "effective" projects devoted 18% of their information material and communications to quality management compared with only 4% in "ineffective" projects. This difference was shown to have a t-test significance of $p<0.01$. Construction managers in "effective" projects devoted less information material to instructions and cost control. The latter finding may point to the place of quality management among the professional duties of a construction management firm; and

Table 6. Characteristics of Communication Topics at the Construction Manager Level—Comparison between "Effective" and "Ineffective" Projects

Topic of communication	"Effective" projects (%)	"Ineffective" projects (%)
Instructions	28	35
Materials and equipment	12	11
Quality management	18	4
Scheduling and coordination	23	23
Cost control	17	25
Other	2	2
Total	100	100

4. A comparison of the planning horizon of the various categories (Fig. 4) showed that the planning horizon of CMs in "effective" projects was relatively longer for construction methods, equipment, allocation of work, and procurement of materials. The CMs in "effective" projects used a planning horizon of 28–57 days compared with 12–30 days in the "ineffective" projects, whereas the planning horizon for the coordination of subcontractors was shorter (23 versus 31) in the "effective" CM category. These gaps are further emphasized by the fact that "effective" projects were found to be smaller in scope ($11 million compared with $21 million).

Conclusions and Recommendations

The study reviewed communication patterns at the CM level in projects delivered by construction management procurement protocol in Israel. The study focused on medium-size building and residential construction projects. Statistical analyses revealed that informal communications continue to be highly important in ensuring the efficiency of the construction manager. Forty-eight percent of the communications at the construction manager level were carried out via verbal means—either in face-to-face meetings or via telecommunication. Fifty-two percent of communications were performed using formal technical means (drawings, printed documents, etc.). The principal channel of communications that affects the overall efficiency of the construction manager's communications was the interactive communication between the construction manager and the design team.

The main conclusions of the study were drawn from a comparative analysis between "effective" and "ineffective" projects, classified according to a composite index which included cost effectiveness, timeliness, planning, quality, and safety criteria. The comparative analysis showed that the CM's capability to communicate effectively with the design team is crucial in over-

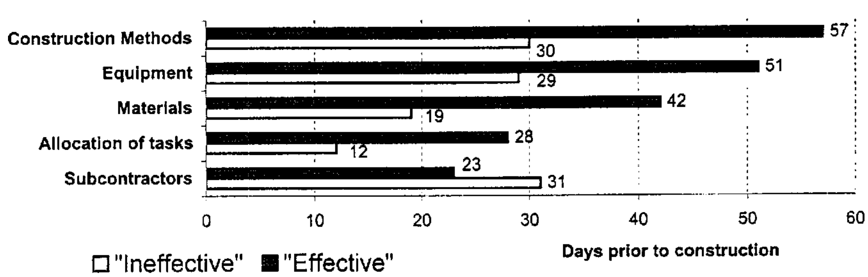

Fig. 4. Average planning horizon (in days), by planning topic—comparison between construction managers in "effective" versus "ineffective" projects

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coming information gaps between the design and construction phases. ‘‘Effective’’ construction managers were capable of introducing design solutions, which also left flexibility for future amendments.

Construction managers in the ‘‘effective’’ projects category implemented longer planning horizons for construction methods, procurement of materials and equipment, and allocation of tasks (between 28–57 days). They devoted 18% of their communications to quality issues (materials, execution, and assurance), compared with only 4% of CM communications in the ‘‘ineffective’’ category. The latter finding leads to the following recommendations:

1. Design capabilities should be an essential qualification required of construction management firms. Despite the fact that professional construction management firms do not perform any designing themselves, they must review and provide engineering solutions for often incomplete or poor design;
2. The area of quality management should receive special emphasis within the scope of the construction manager’s professional responsibilities. Intensive quality management at the construction manager level exhibited a high correlation with high ‘‘effectiveness’’ of projects in terms of timeliness, cost effectiveness, safety, and quality;
3. The study shows that despite the multiple means of electronic communications available, the scope and role of ‘‘informal’’ communications still constitute a significant share of the communications between the construction manager and the other project counterparts. Project effectiveness depends to a great degree on the efficiency of informal communications with the design team, i.e., review of design drawings at an early stage (50–60 days prior to construction);
4. The study shows that the potential of electronic means of communications is not materialized. Formal communications may increase significantly by expanding the use of E-mails for communications between construction managers and the design team, and suppliers; and
5. The planning horizon exhibited by construction managers in the ‘‘effective’’ project category shows that ‘‘effective’’ CMs communicate on the basis of a 30- to 60-day planning horizon. This relatively long planning horizon may be the result of the low degree of precision of the design drawings in this study.

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