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# A model for the development of a building material information system

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**Abstract**

This paper aims to propose a model that enables building material information sharing through a web-based environment by providing access to any sort of up-to-date and accurate building material information on any phase of the building production process. The proposed model provides a mechanism for disseminating classified building material information for decision makers to search for building materials based on the building production phases and effective criteria. Firstly, a field survey was conducted among the main decision makers on building product selection. The survey findings were discussed with a focus group to explore the meanings of survey results at a deeper level and to perform the process analysis for the model development. Then, a process analysis was performed by adopting IDEF-0 technique, to describe the steps and decisions involved in the flow of the building material selection. Accordingly, a model was proposed by coding it with C# language and necessary interfaces were created and tested to show how the system performs. The model enables decision makers to access necessary information in the shortest time and in accordance with the phases of the building production process. With the usage of the model, decision makers can gain time and cost savings by accessing different sort of building material information with less effort and time. The development of the model is an important step for the construction industry in terms of the acquisition of up-to-date and accurate building material information by collecting and distributing all building material information from a single source.

**Keywords**
Building material information, Building production process, Process analysis, Building material information system.

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## 1. Introduction

The building material environment is one of the main fields where a large amount of data is produced in the construction industry. In this environment a wide variety of building materials with different characteristics, price and quality exist together. Besides, with the rapid changes and newly developed materials in the market, it is important for the participants involved in the act of building production, to access adequate building material information throughout the building production process. In this regard, participants are in need of accessing any sort of up-to-date and accurate building material information regardless of time and space.

With the rapid development of information technology, the paper-based methods (catalogues, brochures, and magazines, etc.) have been superseded by digital and web-based systems. However, the content of these web-based systems, even today, are similar to that of paper-based or CD-ROM based catalogues, and provide mechanisms for users to search for materials from any manufacturer by organising and sharing building material information. These mechanisms mostly dealt with making building materials searchable by a classification, and by the attributes of materials. However, the participants' various needs and expectations throughout the building production process have been ignored. As is known well, various participants from different specialties require different sort of building product information in any phase of the building production; from initiation phase to design phase and bidding phase to construction phase. The participants acting on various phases can only make rational decisions in the light of the information available at the time of the decision. Participants should not spend a lot of time and effort to reach the adequate information at the proper phase, and that information should be reached in a short time. Turning now to what currently exists, there is a need of an environment for the acquisition of building material information, where all acting participants' needs and expectations will be taken into consideration throughout the building production process. This paper outlines an integral part of a research project which aims to develop a building material information system. The ultimate purpose of the research is to enable building material information sharing through a web-based environment by providing access to any sort of up-to-date and accurate building material information on any phase of the building production process starting from initiation to the end of construction.

## 2. Background

Several researches have been done in order to develop web-based systems that provide to access required building material information easily and efficiently. One of them is the ARROW, an internet based framework, which provides a mechanism for users to search for materials from any participating manufacturer or supplier based both on specific attributes of a material (Amor and Newnham, 1999). The CONNET project's internet based service provides information about building materials by a classification, which makes building materials searchable by the name of the product or the manufacturer, and by the properties of the product (Amor et al., 2000). A contribution is made by a feature-based modelling approach for material representation which differentiates features for materials; and enables management of material information across firms, projects and in a more global context (van Leeuwen and Fridqvist, 2002). In the scope of GEN projects an open, XML-based, data model for classifications and attributes of materials is developed which enables searching for materials and services (Faux et al., 1998; Debras, 2000). The electronic dissemination of building material information is also enabled through the help of electronic catalogues (Jain and Augenbroe, 2000). Alternative approaches have been described for enabling the use of the performance concept to facilitate material selection from e-catalogues (Jain and Augenbroe, 2002; Jain and Augenbroe, 2003). Nyambayo et al. (2000) reviewed data requirements and the development of the standards for representing manufactured catalogues. Obonyo et al. (2001) offered an approach that helps to gather, query, and interpret data. In the RINET project, an open infrastructure for manufacturers is provided to describe their materials and to upload any type of electronic documentation (RINET, 2000). Another researches concentrated on web-based systems which provides a material search interface for users and an open access to manufacturers' material information (Cope and Amor, 2002; Amor and Kloep, 2003). A product library assistant intranet is presented for organising and sharing online building material information (Coyne et al., 2001; Ofluoglu, 2003). Existing material information delivery methods are reviewed; the applicability of standards is examined; and the requirements for material libraries are identified (Owolabi et al., 2003). A new approach is presented to achieve interoperability between web-based catalogues; and a model of interoperable web-based material catalogue is developed (Kong et al., 2005). A prototype system was developed providing the systematic foundation for document warehouse management of building materials, where multi-type documents can be collected into the central repository and accessed through the web-based tag-manager (Park et al., 2010). Another research aimed to develop building materials database for storing semantic models using the Web of Data technologies (Bilal et al., 2017).

Majority of these researches on the dissemination of building material information found in literature are based on enabling users to search for building materials by classifying and organizing them according to their attributes. Various participants involved at different phases of the building production are seemed to be ignored, although they act as the main decision makers on building material selection. The absence of acting participants, their needs and expectations, and their criteria on selecting building materials pertaining to different phases of building production prevent the effective and efficient usage of existing mechanisms. Thus, these mechanisms do not completely meet the expectations of the participants of the building production process. There is a need of an environment where participants' needs and expectations will be differentiated according to the phases of the building production process. Then, the building material information needed at any phase will be quickly accessed without dealing with unnecessary information. Therefore, this study closes this gap by considering all these factors to enable a more sophisticated search when enabling building material information sharing.

Accordingly, the Building Material Information System (BMIS) research project is conducted in the context of development of a building material information system. This paper presents an integral part of BMIS research project that enables building material information sharing through a web-based environment by providing access to any sort of up-to-date and accurate building material information on any phase of the building production process. In this context, a model is proposed to provide a mechanism for disseminating classified building material information for participants involved in the act of building production to search for building materials based on the phases and effective criteria on building material selection.

## 3. Purpose and methodology

The BMIS research project is undertaken in two parts. The first part of the research project, BMIS-I aimed at enabling a database for manufacturers to gather building materials information by a classification that makes building materials searchable in the same environment. In the context of the BMIS-I, firstly 88 websites providing services to the AEC community from 27 different countries are analyzed to examine the existing situation and to evaluate the building material information being presented on the web all over the world. Then, behaviours and requirements of the supply side and demand side in the acquisition of building material information are studied (Tas and Irlayici, 2007), difficulties in supplying and presenting building material information are evaluated (Tas et a., 2008), and finally BMIS-I database is developed. This database is used as an input for the second part of the research project.

The second part of the research project, BMIS-II aims to propose a model by providing a mechanism in order to disseminate classified building material information, which gathered in BMIS-I, for participants to search for building materials based on the building production phases and effective criteria on building material selection. The methodology of the research project is given in Figure 1.

In order to reach the stated aim, BMIS-II is organised in two phases. In the first phase of BMIS-II, data is collected by a comprehensive field survey in order to determine the behaviours and perspectives of participants acting as decision makers on building material selection (Tas et al., 2013). The findings of the survey are played key roles since they are used as inputs to the second phase of the BMIS-II. Within the scope of Phase-II, a process analysis is performed after a focus group discussion for the development of BMIS model.

The proposed BMIS model considers all the factors given below.

•different sort of building material information is required for the different phases of the building production process;

•different sort of building material information is required by the different participants of the building production process;

•participants make building material selection by considering different criteria;

•participants need to easily access up-to-date and accurate building material information by considering all the factors given above.

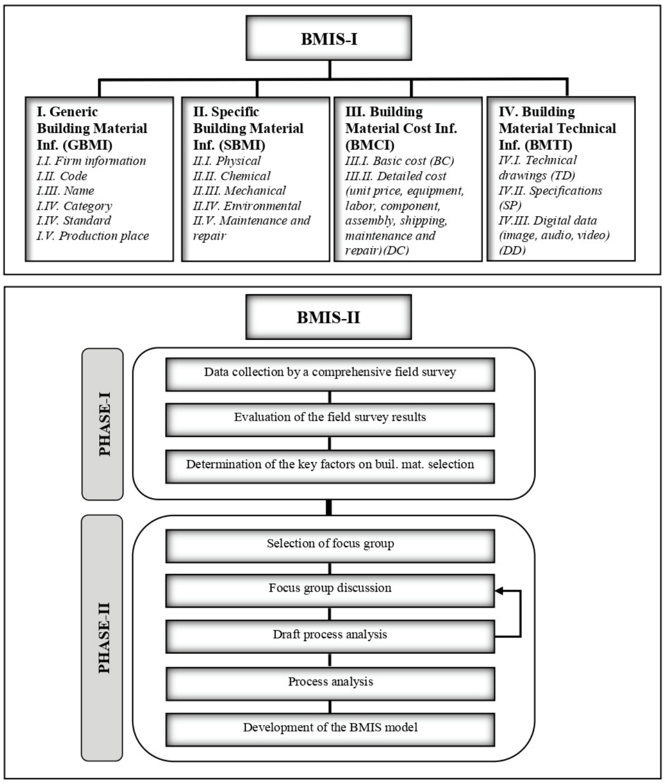



***Figure 1.*** Methodology of the BMIS research project.

## 4. Model development process

The BMIS model development process includes the following steps.

### 4.1. Phase I: Survey results

The field survey is conducted among the design/construction professionals that are the main decision makers on building material selection during the building production process. It is applied with the collaboration of the Building Information Center (YEM), which is a unique information centre that provides services to all users of building materials, including companies engaged in the production of goods or services, professionals, executives, architects, engineers, and contractors in the Turkish construction industry (www.yem.net). The target of the field survey is the members of YEM and the questionnaires are filled through the official website of the YEM. The number of responses of the field survey is 302. However, four are not included in the evaluation because they are not experienced with building materials. In this circumstance, the sampling confidence interval equals 5.23.

The questionnaire is specifically prepared in order to collect data for the process analysis that is necessary for the development of the BMIS model. Accordingly, survey questions aimed to determine:

•what sort of building material information is required for building material selection in different phases of the building production process;

•which criteria affect building material selection in different phases of the building production process;

•which participants act on building material selection in different phases of the building production process.

***Table 1.*** *Profile of the respondents.*

| Construct | Variable | Category | Frequency |
|---|---|---|---|
| Design / Construction professional | Working period (years) | 1-5 | 30 |
| | | 6-10 | 15 |
| | | 11-15 | 16 |
| | | 16-20 | 12 |
| | | >20 | 27 |
| | Working field | Project (PRO) | 5 |
| | | Construction (CON) | 14 |
| | | Consulting (CSL) | 1 |
| | | PRO + CON | 29 |
| | | PRO + CSL | 6 |
| | | CON + CSL | 4 |
| | | PRO + CON + CSL | 41 |
| Firm | Firm age (years) | <1 | 4 |
| | | 1-10 | 44 |
| | | 11-20 | 26 |
| | | 21-30 | 16 |
| | | 31-40 | 4 |
| | | >40 | 6 |
| | Number of employees | 1-10 | 58 |
| | | 11-50 | 15 |
| | | 51-100 | 9 |
| | | 101-500 | 10 |
| | | >500 | 8 |
| | Firm size (annual turnover in thousand USD) | <100 | 20 |
| | | 100-250 | 18 |
| | | 250-500 | 12 |
| | | 500-1000 | 15 |
| | | 1000-5000 | 17 |
| | | >5000 | 18 |

***Table 2.*** *Building material information, effective criteria, and acting participants on building material selection in terms of the phases of building production process.*

| Building Material Information | Initiation Phase | | Design Phase | | Bidding Phase | | Construction Phase | |
|---|---|---|---|---|---|---|---|---|
| | % | Rank | % | Rank | % | Rank | % | Rank |
| Generic building material information | 41.2 | 1 | 69.1 | 2 | 13.1 | 7 | 23.0 | 7 |
| Basic cost information | 22.0 | 2 | 42.3 | 5 | 38.0 | 3 | 29.2 | 6 |
| Detailed cost information | 18.9 | 3 | 27.8 | 7 | 60.8 | 2 | 43.0 | 4 |
| Specific building material information | 19.9 | 4 | 63.2 | 4 | 17.9 | 6 | 43.5 | 3 |
| Specifications | 17.2 | 5 | 40.0 | 6 | 63.6 | 1 | 40.0 | 5 |
| Technical drawings | 16.8 | 6 | 71.1 | 1 | 31.3 | 4 | 45.0 | 2 |
| Digital data (image, audio, video) | 12.4 | 7 | 65.6 | 3 | 27.8 | 5 | 50.5 | 1 |
| **Effective Criteria** | **Initiation Phase** | | **Design Phase** | | **Bidding Phase** | | **Construction Phase** | |
| | % | Rank | % | Rank | % | Rank | % | Rank |
| Project budget | 49.1 | 1 | 46.4 | 5 | 37.8 | 3 | 21.6 | 4 |
| Project concept | 44.3 | 2 | 74.2 | 1 | 6.5 | 6 | 12.0 | 6 |
| Owner's requirements | 44.0 | 3 | 57.7 | 4 | 14.1 | 5 | 18.6 | 5 |
| Project schedule | 23.7 | 4 | 43.0 | 6 | 31.6 | 1 | 48.0 | 3 |
| Construction technology/method | 20.6 | 5 | 62.5 | 2 | 22.0 | 4 | 57.0 | 1 |
| Building material availability | 19.9 | 6 | 59.1 | 3 | 29.6 | 2 | 53.5 | 2 |
| **Participants Acting** | **Initiation Phase** | | **Design Phase** | | **Bidding Phase** | | **Construction Phase** | |
| | % | Rank | % | Rank | % | Rank | % | Rank |
| Owner | 50.9 | 1 | 41.6 | 4 | 33.0 | 2 | 37.1 | 6 |
| Design professionals | 40.0 | 2 | 88.7 | 1 | 24.4 | 5 | 34.0 | 8 |
| Consultants | 34.4 | 3 | 56.0 | 3 | 25.8 | 4 | 38.5 | 5 |
| Building material manufacturers | 20.6 | 4 | 40.0 | 5 | 22.7 | 6 | 53.3 | 3 |
| Users | 20.3 | 5 | 32.6 | 6 | 10.0 | 8 | 49.8 | 4 |
| Construction professionals | 14.4 | 6 | 73.5 | 2 | 28.2 | 3 | 36.1 | 7 |
| Contractors | 8.9 | 7 | 10.0 | 7 | 43.0 | 1 | 63.2 | 2 |
| Subcontractors | 3.8 | 8 | 5.8 | 8 | 17.9 | 7 | 71.5 | 1 |

Table 1 presents general characteristics of the respondents of the field survey. It can be seen that the sample is balanced in terms of its distribution over the categories of the variables related to design/construction professionals and their firms.

In the field survey, respondents are asked (1) to determine what sort of building material information is required, (2) to specify effective criteria on building material selection and (3) to determine which participants act on building material selection in different phases of the building production process. The results are given in Table 2 according to their rates and ranks.

According to the results, required building material information on building material selection differs in each phase of the process. Mostly generic building material information and basic cost information are required during the initiation phase. Respondents determined that all given building material information are required during the design phase. Among these generic and specific building material information and technical drawings have high ranks. On the other hand, specifications and detailed cost information are mostly required during the bidding phase. Digital data (image, audio, video, etc.), technical drawings, specific building material information, detailed cost information and specifications gain importance in the construction phase.

When the results were analyzed, it is shown that different criteria affect building material selection in different phases. For instance project budget, project concept and owner's requirements are the most effective criteria on building material selection during the initiation phase. In the design phase project concept, construction technology/method and building material availability are more effective on building material selection. On the other hand, project schedule and building material availability are the effective criteria in the bidding phase. In the construction phase, the most effective criteria are construction technology/method, building material availability and project schedule.

Survey results showed that different participants play roles on building material selection in different phases. Owner, design professionals, and consultants are the main participants in the initiation phase. In the design phase, design professionals are mostly involved in building material selection. On the other hand, construction professionals and owner are acting in the bidding phase. In the construction phase; construction professionals, building material manufacturers and users have more responsibilities on building material selection.

With the help of the evaluation of survey results, key factors (building material information, effective criteria, and acting participants) on building material selection are determined based on the phases of the building production process. The results prove that during certain phases of the building production process; (1) different building material information is required for building material selection, (2) different criteria affect building material selection, and (3) different participants are involved in building material selection.

### 4.2. Phase II: Focus group discussion

At Phase-II, the evaluated survey results are discussed with a focus group. The focus group discussion is conducted in order to explore the meanings of survey results at a deeper level and to perform the process analysis for the development of BMIS model.

The focus group is selected from the field survey participants acting as the main decision makers on building material selection. Thus, the focus group consists of professionals from three different firms with large work capacities; who also indicated the importance of the development of a building material information system in the field survey. Accordingly, each phase of the building production process is discussed with regard to the key factors on building material selection that are determined with the help of the field survey.

According to the focus group discussion:

Initiation phase: In the initiation phase, owner and architect discuss on the determination of basic building materials regarding the project concept. Owner and architect mainly need generic building material information and basic cost information. Therefore, required information is typically very broad in scope and as such may address only a building material category (concrete, steel, stone, wood, etc.) with some generic building material information. They also consider building material alternatives based on project budget and owner requirements. Thus, field survey and focus group discussion results are similar to each other regarding building material selection in the initiation phase.

Design phase: Design professionals (especially architects) are the main decision makers on building material selection in the design phase. In the schematic design phase, architects discuss building material related decisions with owner. During design development and construction documents phases, architects receive professional support for material selection from consultants (e.g. consultancy on building materials, selection appropriate building material for green building certification, façade consultancy, acoustics consultancy, wind consultancy, etc.).

Although the survey findings showed that project schedule has little effect, focus group determined that project schedule is an effective criterion on building material selection. Project schedule is important on material selection in projects, which have difficulties on delivery of imported building materials. Besides, focus group determined that building material availability is not that important in large-scale projects; because, custom production can be made in case of unavailability. However, building material availability is quite important on material selection in small-scale projects. Focus group also emphasized building material characteristics (life cycle, visuality, environmental characteristics, sustainability, guarantee period, etc.), building material standards, and compliance to construction technology/method gain importance in different stages of the design phase. It is also determined that owner and architect can be willing to use new materials in the market; so using new materials can be a criterion on material selection.

In terms of required information on building material selection, focus group emphasized that specific building material information, technical drawings and specifications are required in the advancing stages of the design phase. Although it has a lower rate according to the survey results, focus group considers detailed cost as important information that should be acquired.

Another important issue that focus

group discussed is the accessibility of building material information. Focus group stated that they have experienced difficulties accessing specific building material information; and in order to overcome the difficulties they benefited from the literature, they especially used foreign hard copies and created their own libraries. They added that although they can easily access generic information from local manufacturer firm's websites, the information given at these websites are not specific enough and they have to meet one-to-one and communicate with firm's representatives in order to get specific material information. In this regard, focus group emphasized a building material information system can be very useful and helpful in order to access sufficient, accurate and up-to-date information.

Bidding phase: According to the focus group discussion, construction documents prepared in the final stages of the design phase are used in the bidding phase. Construction professionals (contractors and subcontractors) play main roles in the bidding phase; they use specifications and detailed cost information, which are specified in the construction documents. Construction professionals try to access these required information through building material manufacturers. Focus group highlighted the importance of a building material information system in terms of accessing required building material information during the bidding phase.

Construction phase: Construction professionals and building material manufacturers play active roles in the construction phase. When the owner is not the user of the building, users also play roles specifically in the determination of finishing building materials related with interior design. Project schedule, construction technology/method and building material availability are effective criteria on building material selection in the construction phase. On the other hand specific building material information, detailed cost information, digital data, technical drawings and specifications are required. In addition, focus group stated although cost is very effective on building material selection; architects do not agree to replace the building material that is specified in the construction documents, they want contractors to search for equivalent material instead.

Therefore, all phases of the building production process are examined by the focus group with regard to key factors on building material selection. The survey findings and focus group discussion helped to perform the process analysis, which is necessary for the development of BMIS model.

### 4.3. Phase II: Process analysis

A process is a sequence of operations, starting with an input in order to achieve a particular output. An understanding of processes can be reached in different ways. The processes are often analyzed to improve coordination and communication through simple mechanisms such as flow charts. To analyze more complex scenarios of real-world phenomena, techniques such as Integrated DEFinition for Function Modeling (IDEF-0) are commonly used (Koskela, 1992; Cooper et al., 2010). IDEF-0 is a modeling technique based on combined graphics and text that are presented in an organized and systematic way (IDEF-0, 1993).

Accordingly, IDEF-0 process modeling method (Hunt, 1996) is adopted to represent the building material selection process as a set of related activities. This technique is selected in this study as it has a common usage (Koskela, 1992; Cooper et al., 2010) and as the most appropriate means of representing processes (Kagioglou et al., 2000). Related leading studies also used IDEF-0 process-modelling method to successfully represent building material selection process (Jain and Augenbroe, 2000; Jain and Augenbroe, 2003).

A process analysis is performed to describe the steps and decisions involved in the flow of the building material selection regarding the phases of the building production process. IDEF-0 is used to break down the process into activities and sub-activities by representing them as a diagram. In IDEF-0, the process is represented by using a hierarchical series of diagrams and is composed of a series of boxes and arrows. An IDEF-0 process diagram shows an activity in the center. Arrows entering from the left side of the box are inputs, which are information or objects required to perform an activity. Controls are shown entering from the top and they specify conditions or circumstances that govern the activities performance. Arrows connected to the bottom side of the box represent mechanisms that are persons or devices that carry out the activity. Outputs are shown leaving from the right; they are information or objects that are created when the activity is performed.

Figure 2 represents the basic concept of the process analysis regarding building material selection. Accordingly, certain phase of the building production process is shown as an activity in the centre of the boxes. Arrows connected from the left side, the top, the bottom and the right side of the boxes are inputs, controls, mechanisms and outputs respectively. Inputs represent building material information necessary for material selection in each phase. Controls serve as effective criteria on building material selection process. Then, mechanisms represent acting participants on building material selection in each phase of the building production process. These are the key factors for the building material selection process.

Firstly, a draft process analysis is done by considering the key factors that are obtained from the evaluation of field survey results and focus group discussion. Then, this draft process analysis is rediscussed with the same focus group. As a result of repeated discussions with the focus group, the draft process analysis is improved and finalized.

In the process analysis, major phases (initiation, design, bidding, and construction) are decomposed into activities that are more detailed. An IDEF-0 diagram as in Figure 3 represents these four main phases of the building production process.

After depicting each phase as an activity (Figure 3) in the process analysis, these are decomposed and followed by sub-activities providing more detail about the phases. The sub-activities for the design phase is illustrated in Figure 4.

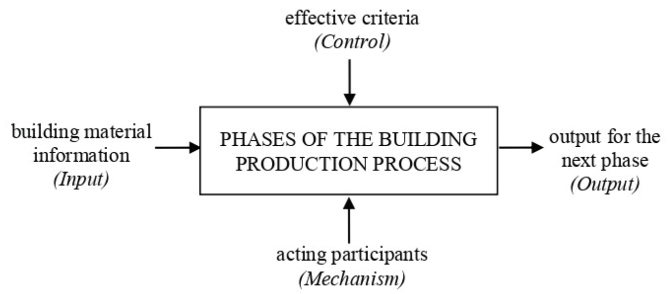



*Figure 2.* The basic concept of the process analysis.

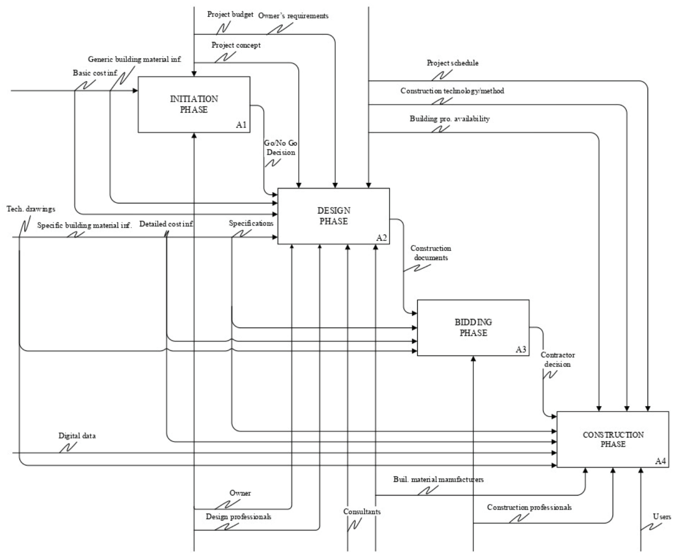



*Figure 3.* IDEF-0 diagram representing building production selection process.

### 4.4. Phase II: development of the BMIS model

The last step of Phase-II is the development of the BMIS model. BMIS model is developed in the light of the findings that are obtained from Phase-I and Phase-II. The model aims to join building material manufacturers and decision makers in the same environment. In this regard, the building material database that is developed in BMIS-I, is integrated to the BMIS model. In the model, building material information required for decision makers in building material selection is provided from the integrated database.

The key factors (building material information, effective criteria, and acting participants) on building material selection specified in the process analysis are adapted to the BMIS model. Accordingly, acting participants are described as "Decision Maker". Building material information is the informa-

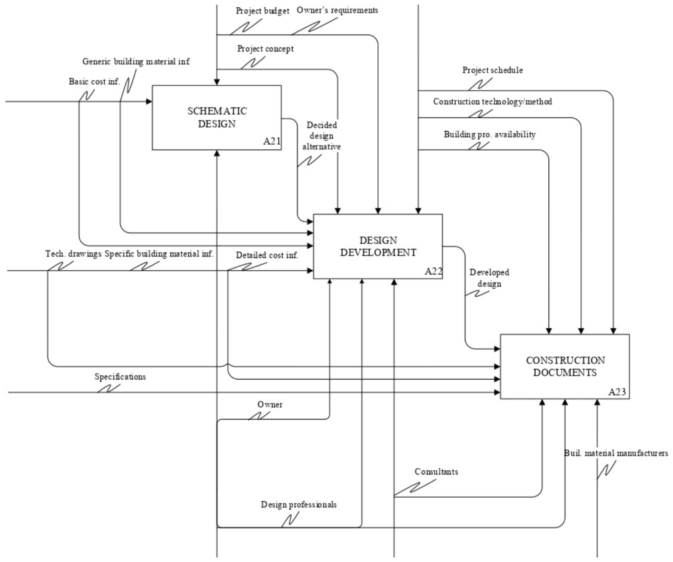



***Figure 4.*** IDEF-0 diagram representing design phase building production selection process.

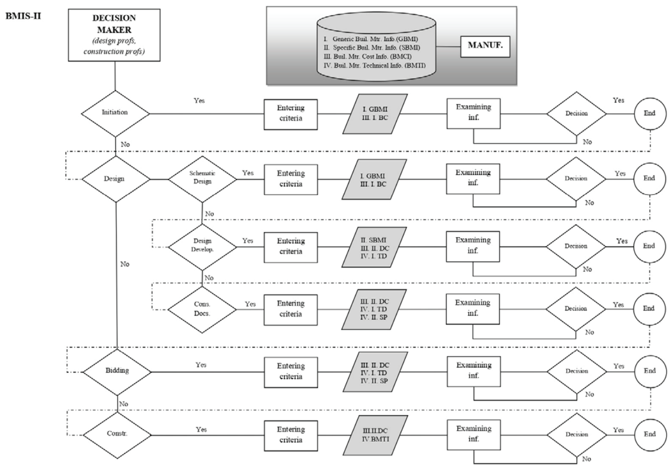



***Figure 5.*** The proposed BMIS model.

tion accessed from the BMIS-I building material database. Effective criteria refer to the criteria affects building material selection through the building production process. These criteria differentiate according to the four main phases of the building production process (initiation, design, bidding and construction phases) in the model. The proposed BMIS model is illustrated in Figure 5.

In the first step of the model, the decision maker selects the relevant phase of the building production process. According to the selected phase, the model presents predefined effective criteria on building material selection. The decision maker defines relevant criteria. The BMIS model filters the necessary building material information from the BMIS-I database according to the criteria that are specified by the decision maker. The search result will give different building materail alternatives along with their information pertaining to performance data, standards, specifications, installation instructions, detailed drawings, and so on. The decision maker examines the filtered building material information and takes the advantage of selection from different alternatives. Unless the decision maker decides on the proper building material, the model allows the decision maker to select the building material by re-examining the filtered information.

The proposed model was implemented by coding with C# language. Necessary BMIS interfaces were created and tested to show how the system performs. Figure 6 shows the interface for building material searching. This interface allows decision maker to search for building materials by specifying different criteria in a certain building product phase.

In order to aid understanding how the model works, an example search in the BMIS building material searching interface was illustrated in Figure 7. The example shows a search that is performed during the design phase for an exterior wall core: lightweight concrete specifically.

The BMIS model filters the necessary information from the BMIS-I database for lightweight concrete according to the block type and block size that are specified by the decision maker. The search result displays lightweight concrete plain block alternatives in a table form for easy comparison. Figure 8 shows the display of search results.

The decision maker can examine the alternatives according to their manufacturers, types, dimensions,standards, physical, chemical and mechanical informations such as thermal conductivity, fire resistance, density, elasticity, and so on. According to the search that is made by the decision maker, adequate information is shown that is required only for the design stage. The decision maker can either decide on the proper lightweight concrete plain block, re-examine the filtered information, or conduct a new search.

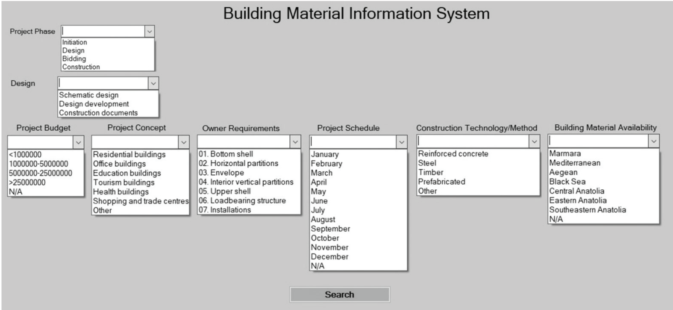



***Figure 6.*** The BMIS building material searching interface.

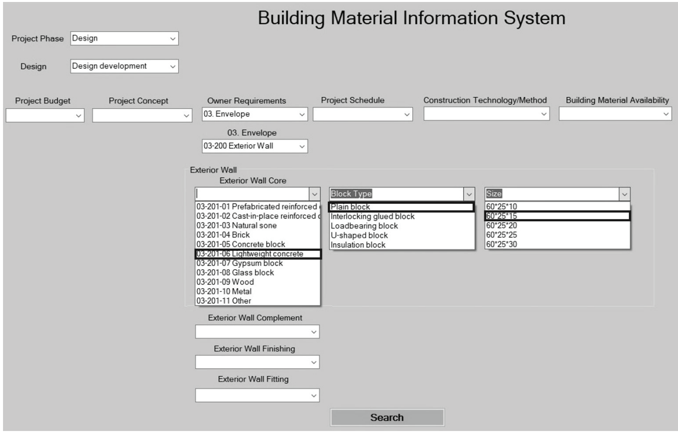
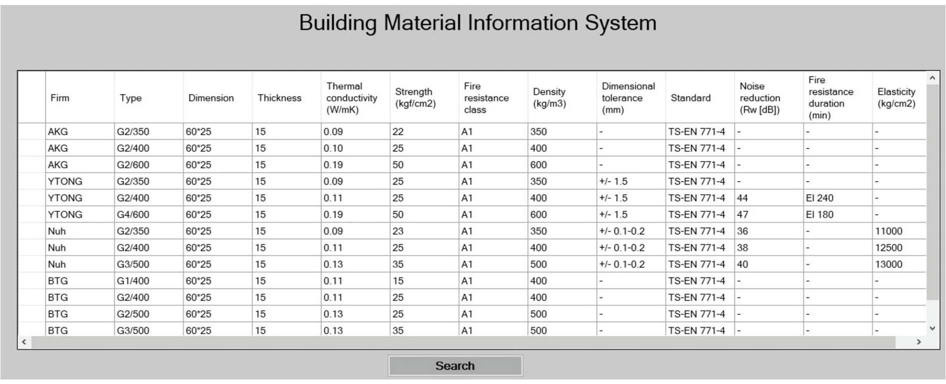



***Figure 7.*** An example search in the BMIS building material searching interface.

## 5. Conclusion

Building material information flow through a building production is very dynamic and occurs during all phases of the building production process. From initiation to design and bidding to construction, participants involved in the act of building production need different sort of building material information. Within this context, they need to utilize such systems that enable access to any sort of building material information from a single source. Several efforts have been made for providing access required building material information (Amor and Newnham, 1999; Cope and Amor, 2002; Amor and Kloep, 2003; Jain and Augenbroe, 2003) and alternative tools have been developed for users to search for materials from any manufacturer (Faux et al., 1998; Amor et al., 2000; Debras, 2000). However, these efforts only helped in organising and sharing building material information by making them searchable by classifications and attributes. Existing tools paid no attention to the participants acting as the main decision makers on building material selection; their needs and expectations were ignored; and their criteria on selecting building materials in different phases of building production were not taken into consideration (Coyne et al., 2001; Ofluoglu, 2003; Park et al., 2010). Therefore, the proposed BMIS model developed in this study closes this gap by considering all these factors to enable a more sophisticated search when enabling building material information sharing. The BMIS model can be regarded as one of the main studies that enable building material information acquisition through a web-based environment by providing access to any sort of up-to-date and accurate building material information on any phase of the building production process. The BMIS is a model that takes into consideration of different sort of building material information required by different participants at the different phases of the building production process.

The BMIS model is proposed with the aim of joining manufacturers and decision makers in the same environment, which provide the acquisition of building material information eas-




| | Firm | Type | Dimension | Thickness | Thermal conductivity (W/mK) | Strength (kgf/cm2) | Fire resistance class | Density (kg/m3) | Dimensional tolerance (mm) | Standard | Noise reduction (Rw [dB]) | Fire resistance duration (min) | Elasticity (kg/cm2) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AKG | G2/350 | 60*25 | 15 | 0.09 | 22 | A1 | 350 | - | TS-EN 771-4 | - | - | - |
| | AKG | G2/400 | 60*25 | 15 | 0.10 | 25 | A1 | 400 | - | TS-EN 771-4 | - | - | - |
| | AKG | G2/600 | 60*25 | 15 | 0.19 | 50 | A1 | 600 | - | TS-EN 771-4 | - | - | - |
| | YTONG | G2/350 | 60*25 | 15 | 0.09 | 25 | A1 | 350 | +/- 1.5 | TS-EN 771-4 | - | - | - |
| | YTONG | G2/400 | 60*25 | 15 | 0.11 | 25 | A1 | 400 | +/- 1.5 | TS-EN 771-4 | 44 | EI 240 | - |
| | YTONG | G4/600 | 60*25 | 15 | 0.19 | 50 | A1 | 600 | +/- 1.5 | TS-EN 771-4 | 47 | EI 180 | - |
| | Nuh | G2/350 | 60*25 | 15 | 0.09 | 23 | A1 | 350 | +/- 0.1-0.2 | TS-EN 771-4 | 36 | - | 11000 |
| | Nuh | G2/400 | 60*25 | 15 | 0.11 | 25 | A1 | 400 | +/- 0.1-0.2 | TS-EN 771-4 | 38 | - | 12500 |
| | Nuh | G3/500 | 60*25 | 15 | 0.13 | 35 | A1 | 500 | +/- 0.1-0.2 | TS-EN 771-4 | 40 | - | 13000 |
| | BTG | G1/400 | 60*25 | 15 | 0.11 | 15 | A1 | 400 | - | TS-EN 771-4 | - | - | - |
| | BTG | G2/400 | 60*25 | 15 | 0.11 | 25 | A1 | 400 | - | TS-EN 771-4 | - | - | - |
| | BTG | G2/500 | 60*25 | 15 | 0.13 | 25 | A1 | 500 | - | TS-EN 771-4 | - | - | - |
| | BTG | G3/500 | 60*25 | 15 | 0.13 | 35 | A1 | 500 | - | TS-EN 771-4 | - | - | - |

***Figure 8.*** The BMIS search result display.

ily and efficiently. The model enables to remove the differences between the manufacturer's methods on disseminating building material information and the decision maker's desires and expectations on obtaining such information. It provides a mechanism for disseminating classified building material information for decision makers to search for building materials based on the building production phases and effective criteria on building material selection. Accordingly, the most important advantage of the BMIS model is to prevent decision makers from losing in too much information when choosing building materials. Another advantage of the BMIS model is to enable decision makers to access necessary information in the shortest time and in accordance with the phases of the building production process and their effective criteria. The model also allows decision makers to determine the most appropriate one from a large number of different material alternatives. Thus, with the usage of the model, decision makers can gain time and cost savings by accessing different sort of building material information with less effort and time. Finally, the development of the BMIS model is an important step for the construction industry in terms of the acquisition of up-to-date and accurate building material information by collecting and distributing all the building material information from a single source.

To conclude, with the help of the BMIS model, different building materials will be comparatively analysed and their characteristics will be evaluated together. Accordingly, the use of the BMIS model will provide to increase the efficiency of the generation of construction projects from the early stages of the design process and; the BMIS model will enable effective decision-making process in the light of up-to-date and accurate building material information. The studies and the model can be regarded as an alternative for other researches that aims to develop similar systems to solve similar problems. In this respect, this study can provide an interactive tool for both academic and practical comparisons on an international basis. However, there are certain limitations which need to be discussed and addressed for further research. The proposed model acts as a package program in its current form. In order to put in practice, it is necessary to establish a collaborative platform that will be shared and integrated by the participants of the construction industry, not only the decision makers but also building material manufacturers. This is one of the main reasons why these studies remain limited in the literature. It is very important and necessary to create these platforms in which collective arrangements are made through collective efforts by providing the common contributions of all implementing ministries, public institutions and organizations, universities, professional chambers and non-governmental organizations.

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