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Developing a Planning Methodology for Purchasing Construction Materials in Iraqi Projects- A Reality Study

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Abstract

Correct procurement of construction materials is linked to the success of projects by preventing additional costs, late arrival of materials, backlogs of materials in warehouses, unfair consumption of natural resources, and others. Many construction projects in Iraq suffer from the lack of a specific strategy for managing procurement operations, which leads to many challenges during project implementation. This paper aims to develop a strategy based on providing a free administrative database for the planning stage during construction materials management, in addition to diagnosing weaknesses and the extent of development needed by each step. Through literary reviews, the most important practices of construction materials were identified. 102 questionnaires were distributed to a group of stakeholders in the field of construction materials management from the government and private sectors, where only 93 completed forms were obtained and valid for analysis, and through a field survey, the degree of application was identified, and by comparing them with the approved degree of conformity to identify the gap between real performance and optimal performance. The field survey included sample selection, questionnaire items, data collection and analysis, and results evaluation. The results of the study showed that there is a clear weakness in planning practices that require necessary corrective measures through the provision of courses and workshops for engineers, in addition to weakness and insufficient understanding of the documentation process and its importance for the rest of the stages of purchasing construction materials.

Keywords: Construction Materials purchasing, critical success factors, Supply Chain Management

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تطوير استراتيجية تخطيط لشراء المواد الانشائية للمشاريع العراقية- دراسة واقعية

سرى طلال القيسي

المستخلص

يرتبط الشراء الصحيح لمواد البناء بنجاح المشاريع من خلال منع التكاليف الإضافية ، وتأخر وصول المواد ، وتراكم المواد في المستودعات ، والاستهلاك غير العادل للموارد الطبيعية ، وغيرها. تعاني العديد من مشاريع البناء في العراق من عدم وجود استراتيجية محددة لإدارة عمليات الشراء ، مما يؤدي إلى العديد من التحديات أثناء تنفيذ المشروع. تهدف هذه الورقة إلى تطوير إستراتيجية تقوم على توفير قاعدة بيانات إدارية مجانية لمرحلة التخطيط أثناء إدارة مواد البناء ، بالإضافة إلى تشخيص نقاط الضعف ومدى التطوير الذي تحتاجه كل خطوة. من خلال المراجعات الأدبية ، تم تحديد أهم ممارسات مواد البناء. تم توزيع 102 استبانة على مجموعة من أصحاب المصلحة في مجال إدارة مواد البناء من القطاعين الحكومي والخاص ، حيث تم الحصول على 93 استمارة فقط مكتملة و صالحة للتحليل ، ومن خلال مسح ميداني تم تحديد درجة التطبيق ، ومن خلال مقارنتها بدرجة المطابقة المعتمدة للتعرف على الفجوة بين الأداء الحقيقي والأداء الأمثل. اشتمل المسح الميداني على اختيار العينة ، وبنود الاستبيان ، وجمع البيانات وتحليلها ، وتقييم النتائج. أظهرت نتائج الدراسة أن هناك ضعف واضح في ممارسات التخطيط ، مما يتطلب الإجراءات التصحيحية اللازمة من خلال توفير الدورات وورش العمل للمهندسين ، بالإضافة إلى ضعف وعدم كفاية الفهم لعملية التوثيق وأهميتها بالنسبة لبقية المجالات. مراحل شراء مواد البناء.

الكلمات المفتاحية : شراء المواد الانشائية، عوامل النجاح الحاسمة، ادارة سلاسل الامداد

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Introduction

Controlling and monitoring the purchasing, storage, transportation, and handling process is known as construction materials management, which is aimed primarily at achieving comprehensive quality and quantity in all stages of construction materials management. Therefore, the management of construction materials is to provide the required materials at the specified time and within the established budget [1]. Control and management of purchasing processes are very important for every project and must be dealt with effectively to complete the project's success. Effective substance management can bring a lot of direct and indirect benefits. Despite their cost weight in the projects, insufficient attention was paid to the mechanisms of material procurement. Managing the planning stages in large projects is required due to the variety and large amount of materials due to the different construction elements in the project **[2]**. Energy consumption is second only to building operating costs. Sustainable technology in the energy sector depends on energy conservation and the use of renewable sources such as wind energy, solar energy, and glazing and insulation systems. Other areas of focus include HVAC and construction methods; sensors and other monitoring systems; and simulation tools that help building designers make more energy-efficient choices **[3]**, [4] indicates that about 60% of the project's capital for projects is material costs. Therefore, the development of standard procedures for the management of construction materials is a vital role**.** Time and cost are the most important factors to consider when planning each project, and their relationship is complex. The total cost for each project is the sum of the direct and indirect costs. Direct cost generally represents labor, construction materials, equipment costs, etc. The indirect cost represents overhead costs such as supervision, management, and consultants. The direct cost grows at an increasing rate compared to the project's progress. However, the indirect cost continues throughout the project's life, and any decrease in the project time means a reduction in the indirect cost, so the availability of a strategy for managing construction materials contributes effectively to controlling project costs [5]**.** Poor management of construction materials also affects the coordination between storage and handling operations at the site, which depends on the accuracy of the information received to provide the appropriate place, conditions, labor, and equipment for the storage and use of construction materials. **[6]**

The planning process is divided into four axes:

- Strategy and policy
- Technical requirements and specifications
- Experiences and qualifications, and
- Documentation

Planning is a mandatory and very important process in projects. Construction Material planning is a key to material management, linked with project planning and controlling setup **[7].** Materials supply chain actions were a set of Procedures that represent the official or accepted way of doing the process of construction materials management. The construction sector is the biggest driver of materials consumption and waste globally. The European Union seeks to move from its traditional resource and waste management system in the construction sector to high circularity **[8].** Factors affecting the management of materials are lost or damaged materials, purchase orders not

fulfilled, materials not received, errors in receiving materials, and discrepancies in orders relative to actual need. Construction materials management systems are primarily related to the planning process **[3].** Procurement includes selecting suppliers, analyzing offers, examining materials supplied, and documenting purchase records. Construction materials management is linked to two important factors. The first is that the specifications of the integrated building materials management system must be made as a strategic decision during the planning stage. The second relates to the supplier selection process being flexible enough to accommodate materials management requirements **[9]**. Since the supply of construction materials goes through eight processes, that is, planning, purchasing, transferring, receiving, storage, handling, waste treatment, and feedback process, the researcher has tracked the important practices during the materials supply chain to explore the procedure and to formulate the proposed actions **[10].** Scheduling the entire construction material program is necessary to meet the project duration **[11].** The building sector is responsible for nearly 40% of raw materials consumption, 36% of energy consumption, 40% of solid waste generation, and 40% of greenhouse gas emissions around the globe. In addition, the building sector is closely related to environmental issues such as dust, photochemical, and water pollution **[12].** The factors effect on the planning process are given in **Table (1)**.

The proposed methodology reduces procurement costs by accurately determining the quantity and time required to request materials, thus increasing project management's efficiency in general. The aim of this research is to develop a strategy based on providing a free administrative database for the planning stage during construction materials management, in addition to diagnosing weaknesses and the extent of development needed by each step. Table 1 shows the effecting factors on planning processes of construction materials management.

Table (1): Affecting factors on planning processes of construction materials management.

	Researcher	Factors
1	Enshassi et al., 2009	1. available of high experience and qualification in the project team 2. Leadership skills for project manager
2	Nann and Aye, 2014	1. undetermined an accurate materials specification 2. the location of materials sources for procurement 3. neglected the forecasting of field conditions and weather 4. neglected Forecasting materials prices in the market 5. weakness in preparation for material storage 6. neglecting required communication for material management 7. weakness in identifying Material Schedule 8. Planning and monitoring construction activities 9. Attention to weather condition 10. Incomplete drawing design and specification 11. Wrong methods and regulations in materials usage 12. Lack of proper work planning and scheduling 13. Incorrect material takeoff from drawing and design document 14. Usage of materials without systematic control
3	Anwar et al., 2015, laith et al., (2018)	1. suitable receipt, inspection procedures for materials implementing 2. weakness of coordination between contractor and supplier

		3. application of utilizing quality assurance(QA) and quality compliance QC plans with the suppliers of major equipment and materials 4. absence of enforcement of law & order situation in the locality 5. Written materials management plans are used throughout the whole life of the project 6. Absence of plans for addressing the effects of change orders on materials 7. Lack of project planning during the construction phase 8. integrated and communicated between project teams
4	Dey, 2001	1. Incorrect materials take off from drawings and design document 2. Subsequent design changes 3. Selection of the Proper type of contract for specific materials procurement

2. Methodology

In preparing the practical part of the research, the researcher relied on the results obtained from the theoretical part, representing the inputs for creating the questionnaire. Through extensive reviews, the researcher reached a set of factors that directly affect the management of construction materials, and these factors were revised through field visits and interviews with experts. The purpose of the expert visits is to present the standard procedures that the researcher has reached to a group of experts to adapt these procedures appropriately for the Iraqi construction sector. The field research methodology included identifying the factors, creating the questionnaire, disseminating the questionnaire to the selected sample, and collecting and analyzing the results of the questionnaire by using the Arithmetic Mean (M). The main objective of the questionnaire is to determine the extent of compliance with materials management standards by assessing the degree of application of these factors when managing construction building materials. Thus, the researcher decided the degree of materials management development required depending on compliance.

2.1 The Field Survey

When determining the factors, the study relied on the following **[13], [14]**:

- Literary reviews
- Central Organization for Standardization and Quality Control (COSQC)
- International Organization for Standardization (ISO) Building Materials 10845 and 17025 [13]
- Expert interviews

The obtained factors were divided into four axes as follows in table (2)**.**

Table (2): Factors affecting the planning stage in materials management

	ITEM
	Strategy and policy
1	The existence of a strategy and policy to coordinate the operations of materials supply can be developed into an integrated system for the management of construction materials.
2	Identify and determine the requirements of the client precisely.
3	Good planning for all processes of construction materials management
4	Continues pursuit to improve the company's performance
5	The existence of a specific and documented Strategy available for all employees
6	The management of construction materials in the company's system is based on scientific foundations,

	and it's good to take and implement decisions.
7	There's a quest for commitment and getting a certificate of international standards.
8	the company analysis and update the factors affecting the management of materials, such as the preparation of databases, methods of decision-making
9	Review the company's policy and continuous development.
10	Put a plan for each process of construction materials management.
11	Make a plan for the risks they may be exposed to the company due to failure In the management of pre-construction materials and before starting the project.
12	coordination between the construction materials management and project management
13	The existence of consensus between the functional structure and structural work (directing tasks for an eligible administratively and technically)
14	The presence of bonuses or rewards and incentives
	Technical requirements and specifications
1	Determine the specification of construction materials required precisely.
2	Adoption of the standard issued by the Iraqi Central Organization for Standardization and Quality Control (COSQC)
3	continuous review of the standard of the International Organization for Standardization (ISO)
4	Adoption of the standard issued by 6the American Society for Testing and Materials (ASTM)
5	Calculate quantities accurately and review to ensure that any error in the appreciation of
6	Review and audit, and approve designs by designers or consultants
7	Publish and circulate specifications, policies, and procedures with adequate training.
	Experiences and qualification
1	The existence of competent and efficient staff to estimate quantities of construction materials
2	Training for using modern techniques and programs to estimate the amounts of construction materials
3	continuous training for managers and technicians to ensure that they keep up with the latest technologies in the field of construction materials management
4	Planners have on-site experience.
5	The existence of criteria to assess the expertise of employees
6	The existence of training courses in coordination with experienced management in the field of construction materials
	Documentation
1	Documenting the methods of selecting construction materials used in the Project
2	Provide documents relating to designs and develop a planning process.
3	Ratify the validity of the documents before they are issued.
4	Documenting the methods of selecting construction materials used in the Project

3. Data Analysis

The questionnaire was in Arabic with understandable terminology so that the respondent could answer it accurately. It included four main axes, and each had several factors affecting the management of construction materials.

1. **The Arithmetic Mean (M)**,

It refers to the evaluation of the questionnaire answers and the rate used in the analysis of each paragraph of the questionnaire and calculated the arithmetic mean from the following equation [15]**:**

$$\mathbf{M= [\sum Xi*fiN]} \quad \mathbf{(1)}$$

Where:

M is the Arithmetic Mean (Weighted average for answers).

Xi is the Grading range's average of the item (Weight Value (WV))

Fi is the Frequency of responses

N is the Number of respondents

A Weight Value is calculated for each of the five interval classes of the obtainable answers to calculate the Arithmetic Mean. This Weight Value (WV) is chosen to represent the mid- of each interval. Table 3 shows the Weight Value of the Frequencies.

Table (3): The Weight Value of the Frequencies [16]

Class Interval	Weight Value (WV)	Class Interval
0-20	10	Never
20-40	30	Seldom
40-60	50	Sometimes
60-80	70	Often
80-100	90	Always

The analysis is based on extracting the median of the weighted average value, representing the average (10-90), where it was (m = 50). The weighted average for each item of the questionnaire was determined as follows **(Al-Ani, 2006):**

- If (M 50>), the application assessment of this practice should be (Poor), and the level of development required should be (Must).
- If (>50M 70>), the application assessment of this practice should be (Middle), and the level of development required should be (Wanted).
- If (M70<), the application assessment of this practice should be (Good), and the level of development required should be (Desired).

3.2 Conformance Ratio (Cr)

This formula is used to evaluate each of the main axes of the questionnaire (four axes), as this ratio gives a perception of the degree of application of each axis in the Iraqi construction sector so that the researcher can determine the gap between the reality of the situation and the required minimum as in Eq. (2)**, [14]:**

$$Cr = M^* Xmax \quad (2)$$

Where:

Cr is the Conformance Ratio for the axis

M is the Arithmetic Mean (Weighted average of the items)

X max: The highest degree of values and occupies the top tier of the importance of the answers center = 90

The analysis and responses evaluation of the axis depends on the extract of the axis Conformance Ratio by locating the median value between (10-90), which was (m=50), then determining the lower limit and the upper limit, by dividing the median and upper value thereof at the highest degree values of the classes Center, which equals (90), to find the lower limit and the upper limit **[17].** Table 4 shows the data analysis of questionnaire results.

- The lower limit = 50/90 which equal to 0.55
- The upper limit =70/90 which equal to 0.77

The axis of processes can be evaluated according to the following:

- If (Cr 0.55>), the level of application of the axis is (Poor), and the level of development is (Must).
- If (0.55≥Cr≥0.77), the level of application of the axis is (Middle), and the level of development is (Wanted).
- If (Cr< 0.77), the level of application of the axis is (Good), and the level of development is (Desired).

Table (4): Data analysis of questionnaire results

	factor	Observed Frequency			M%		Application Degree	Application Assessment		Development Required
		10	30	50	70	90				
f1	There are strategy and policies of a private company to coordinate the operations of materials supply can be developed into an integrated system for the management of construction materials	6	26	30	17	14	48.5	sometimes	Poor	Must
f2	Identify and know the requirements of the client precisely	16	37	23	16	0	60.9	often	Middle	Wanted
f3	Good planning for all processes of construction materials management	21	17	45	10	0	60.5	often	Middle	Wanted
f4	Continues pursuit to improve the company's performance	16	41	26	10	0	63.5	often	Middle	Wanted
f5	The existence of a specific and documented Strategy available for all employees	5	33	21	18	16	48.5	sometimes	Poor	Must
f6	The management of construction materials in the company's system is based on scientific foundations, and it's good to take and implement decisions in the company	15	23	44	11	0	59.0	sometimes	Middle	Wanted
f7	There's a quest for commitment and getting a certificate of international standards	34	12	33	14	0	64.2	often	Middle	Wanted
f8	the company analysis and update the factors affecting the management of materials, such as	7	24	27	35	0	50.6	sometimes	Middle	Wanted

	the preparation of databases, methods of decision-making									
f9	Review the company's policy and continuously developing	11	27	40	14	1	57.1	sometimes	Middle	Wanted
f10	Put a plan for each process of construction materials management	4	21	30	21	17	44.4	sometimes	Poor	Must
f11	Make a plan for the risks they may be exposed to the company as a result of failure In the management of pre-construction materials and before starting the project	12	10	38	14	19	46.1	sometimes	Poor	Must
f12	coordination between the construction materials management and project management	11	25	32	23	2	54.3	sometimes	Middle	Wanted
f13	The existence of consensus between the functional structure and structural work (directing tasks for an eligible administratively and technically)	6	36	28	19	4	54.5	sometimes	Middle	Wanted
f14	The presence of bonuses or rewards and incentives	29	28	20	14	2	64.6	often	Middle	Wanted
f15	Determine the specification of construction materials required precisely	44	33	14	2	0	75.6	often	Good	Desire
f16	Adoption of the standard issued by the Iraqi Central Organization for Standardization and Quality Control (COSQC)	33	31	29	0	0	70.9	often	Good	Desire
f17	Adoption of the standard of the International Organization for Standardization (ISO)	9	39	32	13	0	59.5	sometimes	Middle	Wanted
f18	Adoption of the standard issued by 6the American Society for Testing and Materials (ASTM)	40	20	18	14	1	68.1	often	Middle	Wanted
f19	Calculate quantities accurately	2	43	26	0	0	69.6	often	Middle	Wanted

	and review to ensure that any error in the appreciation of	4								
f20	Review and audit, and approve designs by designers or consultants	11	27	40	14	1	57.1	sometimes	Middle	Wanted
f21	Specifications are announced officially and clear	30	40	22	1	0	71.3	often	Good	Desire
f22	The existence of competent and efficient staff to estimate and limited quantities of construction materials	17	43	31	2	0	66.1	often	Middle	Wanted
f23	Training for using modern techniques and programs to estimate and limit the amounts of construction materials	5	18	43	9	18	46.3	sometimes	Poor	Must
f24	Participation of managers and technicians in training sessions, according to their competence, also subjected to periodic tests by professional actors and certified to make sure that the permanent process of planning and implementation readiness	6	19	40	8	20	46.3	sometimes	Poor	Must
f25	Planners have on-site experience	15	27	41	10	0	60.1	often	Middle	Wanted
f26	The existence of criteria to assess the expertise of employees	2	11	40	37	3	44.0	sometimes	Poor	Must
f27	The existence of training courses in coordination with experienced management in the field of construction materials	2	12	39	37	3	44.2	sometimes	Poor	Must
f28	Documenting the methods of selecting construction materials used in the Project	15	38	32	8	0	62.9	often	Middle	Wanted
f29	Provide documents relating to designs and develop a planning process	35	25	30	3	0	69.8	often	Middle	Wanted
f30	Ratify the validity of the	3	36	20	3	0	71.7	often	Good	Desire

	documents before they are issued	4								
f31	Documenting the methods of selecting construction materials used in the Project	34	34	12	11	2	68.7	often	Middle	Wanted

4. Results and Discussion

By analyzing the questionnaire results, it was found that the highest degree of compliance was with the axis (technical specifications and requirements), with a conformity rate of 75% with the approved standards. However, the rate of development is required in this axis, as its degree of compliance falls within the (medium) range. Then comes the axis (documentation), with a degree of compliance of 76% and a degree of development (required). The least compliant axis was the axis of strategies and policies, with a degree of compliance of only 61%. The results confirm that the stages of the process of purchasing construction materials still need to be developed by introducing modern methods in managing supply chains and relying on the experiences of developed countries in this aspect. The researcher investigates the reality of the application of the most important practices for the construction materials during the planning process. Table 5 shows the analysis and responses evaluation of each axis in the planning process.

Table (5): The Analysis and Responses Evaluation of Each Axis in the Planning Process

No.	Axes of Planning Process	M%	Cr	Degree of Application	Degree of Development
1	Strategy and policy	55.5	0.61	Middle	Wanted
2	Technical requirements and specifications	67.4	0.75	Middle	Wanted
3	Experiences and qualification	51.2	0.57	Middle	Wanted
4	Documentation	68.3	0.76	Middle	Wanted

Table (5) includes the axes of the planning process, which involve the important practices that should be applied to achieve effective management during the planning process. The researcher divided the planning process into four axes:

- Strategy and policy;
- Technical requirements and specifications;
- Experiences and qualifications;
- Documentation

During the analysis and responses evaluation of each axis in the planning process can determine the conformance ratios (Cr) of the planning process axes were 0.61, 0.75, 0.57, 0.76, which reflects the negligence of the application of the practice in the management of construction materials, which will reflect negatively on the project as a whole. These findings refer to – Wanted- degree of development. In this case, the (Cr) analysis and evaluation of the planning process was 0.67, which refers to –Middle- degree of assessment. Figure (1) shows conformance ratio of planning process axis.

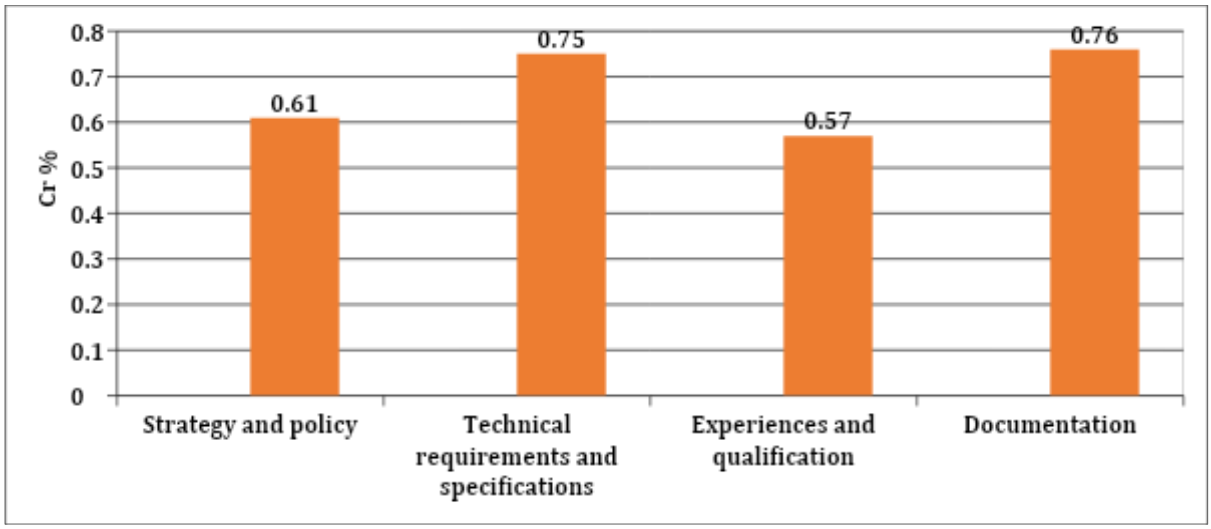

Figure (1): Conformance Ratio of Planning Process Axis

To provide an overview of the degree of application of materials management standards during the implementation phase. table 6 shows the compliance rate of the four axes, representing the degree of compliance in the planning phase.

Table (6): Degree of compliance in the planning phase

Construction Materials Management Processes	M%	Cr	Degree of Application	Degree of Development
Planning Process	60%	0.67	Middle	Wanted

Table (6) shows a general weakness in all construction materials management planning levels. Therefore a general improvement should be taken into account in the planning phase.

5. The Proposed Corrective Action

In developing the proposed methodology, the researcher relied on the importance of defining roles and responsibilities from the beginning to avoid repetition or lack of roles and continuous review of the validity of these roles, as it is an important step before embarking on the technical aspect of building materials management. The proposed methodology also focused on integrating the procedures taken before moving to a new stage by verifying the suitability of materials and quantities for the amounts required, emphasizing the use of building information modeling techniques to ensure the completion of engineering requirements. Diagnosing potential risks is an important procedure in managing construction materials, which has been focused on in the proposed methodology by developing preventive or remedial plans to overcome them. The proposed method focused on validating all inputs related to the management of building materials by specialists, with the need for a comprehensive review of the stages of the procurement process, such as matching the required materials,

controlling receipt, preparing stores, dealing with materials on site, and others.

According to the diagnosis of weaknesses and the results taken from the questionnaire, the researcher suggested several procedures that align with the reality of the Iraqi construction sector and follow the approved guidelines simultaneously. The proposed methodology included the four axes that were mentioned earlier, which are:

- Strategy and policy: the companies must have a suitable plan and policy to coordinate the operations of materials supplying that can be monitored and redeveloped into an integrated system for the construction materials
- Technical requirements and specifications: determine the specification and regulation of construction materials required precisely and review, audit, and approve designs by consultants in supply chains. In addition to using new technology like building information modeling and sustainable concepts.
- Experiences and qualification: Participation of all stakeholders in training sessions, according to their competence, is also subjected to continuous tests by experts and certified parties to ensure that all planning and implementation practices are slandered.
- Documentation: Document all methods at every purchasing level to ensure a database for other projects and check the documents' validity before they are issued.

Figure 2 illustrates a proposed methodology for the planning phase.

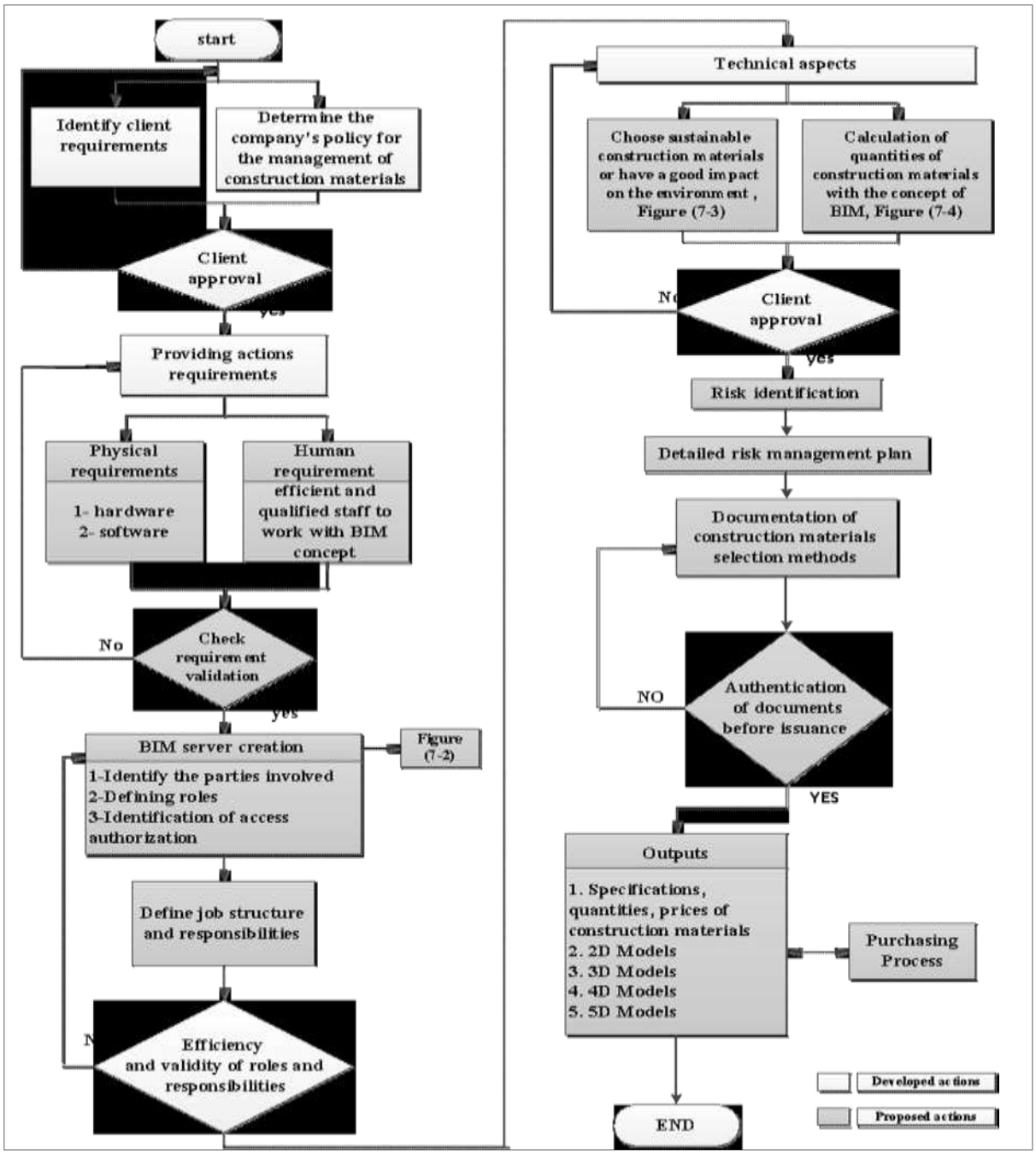

Figure (2): The Proposed Planning Actions for Construction Materials Management

This research contributed to determining the status of construction materials management in Iraq and the extent to which internationally approved standard procedures are followed, in addition to developing a methodology for managing construction materials based on risk management. The proposed method relied on a participatory role between stakeholders involved in materials management by creating public and private policies, emphasizing continuous review and feedback for the continued growth of materials management. The developed methodology took into account modern techniques to control materials management, such as sustainable materials and building information modeling, as it is one of the latest technologies used in construction today. The developed methodology focused on the documentation stage by properly

archiving information and data that is easy to access when needed.

6. Conclusions

Construction materials management has always been very important and significantly reduces project costs. Through the results of the above research, the researcher reached a set of conclusions related to the literary review, field visits, and questionnaires, and finally, the results obtained as shown below:

- The absence of proper planning reflects negatively on the rest of the stages, being the most important stage, and failure in it leads to a series of problems in the rest of the steps.
- A general weakness in adopting the international procedures or standards followed, such as the contractor or the client, to develop his work in the management of building materials, where the (Cr) of analysis and evaluation of planning process was 0.67, which refers to –Middle- degree of assessment.
- The field survey found that the procurement contracts are referred to the lowest cost bidder, which constitutes another burden on the supply chain due to the weakness of the supplying parties from contractors or subcontractors.
- Emphasizing the need to introduce new technologies when managing construction materials, such as building information modeling and the concept of sustainability, as they are among the modern concepts that greatly help to improve materials management by reducing time and effort, reducing errors, and thus reducing the costs of construction materials.
- Weakness of the documentation process and lack of interest in the feedback process leads to a significant defect in the quality of supply chains with a low "implementation score" equal to 0.53 due to the lack of an electronic database utilizing previous projects as databases.

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