Material Procurement Management for Construction Projects: A Database Approach

by

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1. INTRODUCTION

Material procurement is a critical component of construction project management, as it has a direct impact on project success in terms of budget, schedule, and quality. Conventional methods of procurement frequently rely on manual procedures, which cause delays and inefficiencies. By automating procedures, centralizing procurement data, and enabling real-time tracking of materials and supplier performance, a database-driven system presents a more effective method.

This Article describes a database-driven material procurement management system for construction projects that is intended to improve communication, optimize resource allocation, and guarantee on-time material delivery. This approach seeks to enhance productivity and project results by addressing the drawbacks of conventional techniques.

2. MISSION

The mission is to enhance decision-making, ensure accuracy, optimize resource allocation in construction projects through a streamlined Procurement Management System.

3. OBJECTIVE

1. Build an Efficient Database System :-

The goal is to centralize procurement data, including materials, suppliers, orders, and inventory, into a well-structured database. This system will ensure quick access to accurate information, reduce errors, and support automated workflows, leading to better decision-making and more efficient procurement processes in construction projects.

2. Streamline Procurement Process:-

Automate and centralize material procurement activities to improve workflow efficiency and reduce manual errors.

3. Optimize Resource Allocation:-

Improve resource planning by managing material availability, minimizing waste, and reducing costs associated with delays or overstocking

4. Enhance Decision-Making :-

Provide real-time data and insights to support informed decision-making in material sourcing, inventory control, and supplier selection.

4. SYSTEM DESIGN AND DATABASE SCHEMA

4.1 Database Overview :-

The Material Procurement Management Database serves as the foundation of the entire system, capturing and managing all relevant procurement data in real-time. This centralized repository supports key functions like tracking material availability, managing supplier information, and processing purchase orders. The system is designed using dimension and fact tables to store and manage data related to supplier, client , department, warehouse, inventory, supplymaterial, delivery, order. procurement, materials, projects, and employees.

4.2 Key Entities and Table Definitions:-

The database is structured around the core elements of procurement, ensuring that all entities are properly defined and relationships between them are mapped.

I. Suppliers Table :-

Purpose: Stores information about suppliers who provide materials for construction projects.

SupplierID (Primary Key): Unique identifier for each supplier.
SupplierName: Name of the supplier.

ContactPerson: The individual representing the supplier for communications.
ContactNumber: Phone number of the supplier.
Email: Email address of the supplier (must be unique).
Address: Physical address of the supplier's office or warehouse.

II. Client Table :-

Purpose: Stores information about clients who commission construction projects.

ClientID (Primary Key):   Unique identifier for each client.
ClientName: Name of the client or organization.
ContactPerson: The primary contact person for the client.
ContactNumber: Phone number of the client.
Email: Email address of the client (must be unique).
Address: Physical address of the client.

III. Material Table :-

Purpose: Stores information about the materials required for construction projects.

MaterialID (Primary Key):   Unique identifier for each material.
MaterialName: Name of the material.
UnitPrice: Cost per unit of the material.
UnitOfMeasure: The standard unit of measure for the material (e.g., kilograms, liters).

IV. Order Table :-

Purpose: Tracks purchase orders for materials made for construction projects.

OrderID (Primary Key):   Unique identifier for each order.
SupplierMaterialID (Foreign Key):   Links to the SupplierMaterial Table, representing the supplier and material
ProjectID (Foreign Key):   Links to the Project Table, representing the project for which the materials are ordere
OrderDate: The date when the order was placed.
QuantityOrdered: The amount of material ordered.
TotalCost: The total cost of the ordered materials.
EmployeeID (Foreign Key):   Links to the Employee Table, representing the employee who processed the order.

V. Inventory Table :-

Purpose: Tracks material availability across various warehouses.

InventoryID (Primary Key):   Unique identifier for each inventory record.
SupplierMaterialID (Foreign Key):   Links to the SupplierMaterial Table, representing the supplier and material
WarehouseID (Foreign Key):   Links to the Warehouse Table, representing where the material is stored.
QuantityOnHand: The current quantity of material available in the warehouse.
ReorderLevel: Minimum threshold of material before reordering is triggered.
LastUpdated: The date when the inventory record was last updated.

VI. Employee Table :-

Purpose: Stores essential information about the employees involved in procurement activities.

EmployeeID (Primary Key): Unique identifier for each employee.
FirstName: First name of the employee.
LastName: Last name of the employee.
Position: The role or position held by the employee.
ContactNumber: Phone number of the employee.
Email: Email address of the employee (must be unique).
DepartmentID (Foreign Key): Links to the Department Table, representing the department the employee belongs

VII. Department Table :-
Purpose: Stores information about the departments involved in procurement and related operations.

  DepartmentID (Primary Key): Unique identifier for each department.
  DepartmentName: Name of the department (e.g., Procurement, Finance, etc.)

VIII. Warehouse Table :-
Purpose: Stores information about the warehouses where materials are stored.

  WarehouseID (Primary Key): Unique identifier for each warehouse.
  WarehouseName: Name of the warehouse.
  Location: Physical location of the warehouse.
  Capacity: Storage capacity of the warehouse (measured in a standard unit, e.g., cubic meters).

IX. Project Table :-
Purpose: Stores information about the construction projects managed by the company.

  ProjectID (Primary Key): Unique identifier for each project.
  ClientID (Foreign Key): Links to the Client Table, representing the client who commissioned the project.
  ProjectName: Name of the project.
  StartDate: The starting date of the project.
  EndDate: The expected completion date of the project.
  Location: Physical location where the project is being carried out.
  Budget: Total budget allocated for the project.

X. SupplierMaterial Table :-
Purpose: Establishes a relationship between suppliers and the materials they provide.

  SupplierMaterialID (Primary Key): Unique identifier for each supplier-material combination.
  SupplierID (Foreign Key): Links to the Suppliers Table, representing the supplier.
  MaterialID (Foreign Key): Links to the Material Table, representing the material supplied.

XI. Delivery Table :-
Purpose: Tracks the delivery of materials to project sites.

  DeliveryID (Primary Key): Unique identifier for each delivery.
  OrderID (Foreign Key): Links to the Order Table, representing the order that is being delivered.
  EmployeeID (Foreign Key): Links to the Employee Table, representing the employee responsible for the deliver
  ProjectID (Foreign Key): Links to the Project Table, representing the project receiving the delivery.
  DeliveryDate: The date when the materials were delivered.
  QuantityDelivered: The amount of material delivered.
  DeliveryNotes: Any additional notes or remarks related to the delivery.

4.3 Constraints and Integrity Rules:-

Primary Key Constraints: Ensure unique identifiers for each entity (e.g., ProjectID, MaterialID, SupplierID).

Foreign Key Constraints: Maintain relationships between tables (e.g., SupplierID in Order Table links to Supplier Table).

Not Null Constraints: Ensure essential fields (e.g., ProjectName, OrderDate, QuantityOrdered) are always populated.

Check Constraints: Example: CHECK (Budget >= 0) for the Project Table to prevent negative budgets. ○ CHECK (Status IN ('Pending', 'Delivered', 'Late')) in Delivery Table to maintain consistency.

5. ENTITY RELATIONSHIP

An **Entity-Relationship Diagram (ERD)** is a visual representation of the entities within a system and the relationships between those entities. It is a key tool in database design, helping to illustrate the structure and organization of data in a relational database. Fig 1 illustrates the entity relationship diagram showing relations within tables.
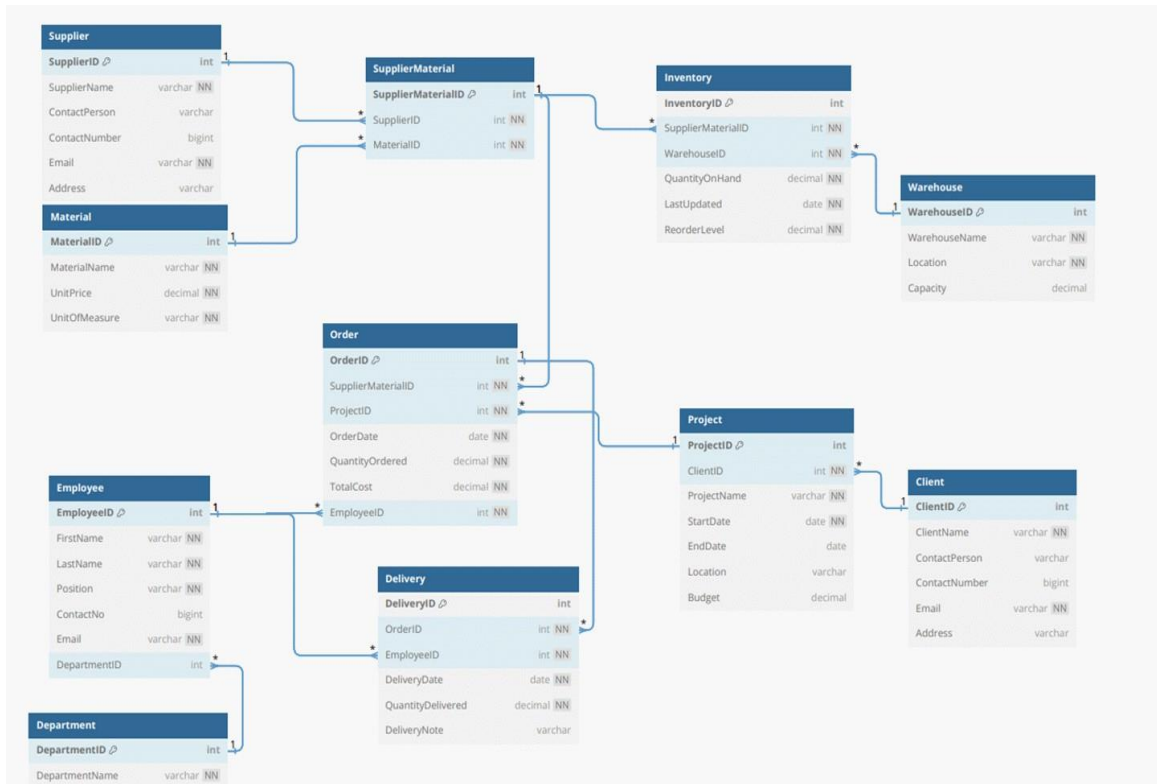

Fig 1. Entity Relatshionship Diagram

Client ↔ Project(one to many): One client can have multiple projects.

Supplier ↔ Material(many to many) : One supplier can provide multiple materials and vise versa

SupplierMaterial ↔ Inventory(one to many): One supplier-material combination can be found in many inventories.

Warehouse ↔ Inventory(one to many): One warehouse can store multiple inventories.

Project ↔ Order(one to many): Each project can have multiple orders.

SupplierMaterial ↔ Order(one to many): Each order contains one supplier-material pair.

Employee ↔ order(one to many): One employee handles multiple orders.

Order ↔ Delivery(one to many): Multiple deliveries can be associated with a single order.

Employee ↔ Delivery(one to many): One employee may handle multiple deliveries.

Department ↔ Employee(one to many): Each department can have multiple employees

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6. CONCLUSION

Implementing a robust Material Procurement Management System is crucial for the efficient handling of resources for construction projects. A well-designed database helps in maintaining accurate records and optimizing inventory. The proposed database structure, which integrates clients, suppliers, materials, orders, deliveries, and employees, provides a comprehensive view of all procurement processes. This system will ultimately support the success of procurement company and construction projects by ensuring timely and effective material management.

A. Appendix: Dimension and Fact Tables Overview

The following appendices provide detailed descriptions of the **Dimension** and **Fact Tables** used in the Material Procurement Management Database. Each table is designed to store specific information about the entities involved in the procurement process, supporting efficient data management and decision-making.

Dimension Tables

Suppliers Table:

Primary Key: SupplierID is the primary key, ensuring that each supplier record is unique and cannot be NULL.

Unique Constraint: Email is a unique field, ensuring that no two suppliers can have the same email address.

Field	Data Type
SupplierID	INT (Primary Key)
SupplierName	VARCHAR (255)
ContactPerson	VARCHAR (255)
ContactNumber	BIGINT
Email	VARCHAR(255)
Address	VARCHAR(255)

Client Table

Primary Key: ClientID is the primary key, ensuring uniqueness and non-nullability.

Unique Constraint: Email is unique, so duplicate emails are not allowed.

Field	Data Type
ClientID	INT (Primary Key)
ClientName	VARCHAR(255)
ContactPerson	VARCHAR(255)
ContactNumber	BIGINT
Email	VARCHAR(255) UNIQUE
Address	VARCHAR(255)

Employee Table:

Primary Key: EmployeeID is unique and cannot be NULL.

Foreign Key: DepartmentID references the Department table, establishing a link between employees and departments, enforcing referential integrity.

Unique Constraint: Email ensures that no two employees can have the same email address.

Field	Data Type
EmployeeID	INT (Primary Key)
FirstName	VARCHAR(255)
LastName	VARCHAR(255)
Position	VARCHAR(255)
ContactNumber	BIGINT
Email	
DepartmentID	INT(Foreign key)

Project Table:

Primary Key: ProjectID ensures each project record is unique.

Foreign Key: ClientID links to the Client table, enforcing referential integrity between projects and their respective clients.

Field	Data Type
ProjectID	INT PRIMARY KEY
ClientID	INT (Foreign key)
ProjectName	VARCHAR(255)
StartDate	DATE
EndDate	DATE
Location	VARCHAR(255)
Budget	DECIMAL(10, 2)

Warehouse Table:

Primary Key: WarehouseID uniquely identifies each warehouse.

Material Table:

Primary Key: MaterialID uniquely identifies each material.

Field	Data Type
WarehouseID	INT (Primary Key)
WarehouseName	VARCHAR(255)
Location	VARCHAR(255)
Capacity	DECIMAL(10,2)

Field	Data Type
MaterialID	INT (Primary Key)
MaterialName	VARCHAR (255)
UnitPrice	DECIMAL(10,2)
UnitOfMeasure	VARCHAR

Inventory Table :

Primary Key: InventoryID uniquely identifies each inventory record.

Foreign Keys:
SupplierMaterialID references SupplierMaterial, linking inventory to specific supplier materials.
WarehouseID links to the Warehouse table, ensuring inventory is associated with a warehouse.

Field	Data Type
InventoryID	INT (Primary Key)
SupplierMaterialID	INT (Foreign Key)
WarehouseID	INT (Foreign Key)
QuantityOnHand	DECIMAL(10,2)
LastUpdated	DATE
ReorderLevel	DECIMAL(10,2)

Department Table:

Primary Key: DepartmentID uniquely identifies each department and cannot be NULL.

Field	Data Type
DepartmentID	INT (Primary Key)
DepartmentName	VARCHAR(255)

Fact Table

Delivery Table
Primary Key: DeliveryID uniquely identifies
Foreign Keys:
OrderID links to the Order table, connecting deliveries to
EmployeeID links to the Employee table, identifying who
ProjectID connects the delivery to a specific project.

Field	Data Type
DeliveryID	INT (Primary Key)
OrderID	INT (Foreign Key)
EmployeeID	INT(foreign Key)
ProjectID	INT(foreign Key)
DeliveryDate	DATE
QuantityDelivered	DECIMAL(10,2)
DeliveryNotes	VARCHAR

Order Table
Primary Key: OrderID ensures each order is unique.
Foreign Keys:
SupplierMaterialID links to the SupplierMaterial table, connecting
ProjectID links to the Project table, relating orders to projects.
EmployeeID links to the Employee table, identifying the employee who

Field	Data Type
OrderID	INT (Primary Key)
SupplierMaterialID	INT (Foreign Key)
ProjectID	INT (Foreign Key)
OrderDate	DATE
QuantityOrdered	DECIMAL(10,2)
TotalCost	DECIMAL(10,2)
EmployeeID	INT(foreign Key)

SupplierMaterial Table
Primary Key: SupplierMaterialID uniquely identifies each supplier-material record.
Foreign Keys:
SupplierID links to the Supplier table, associating materials with suppliers.
MaterialID links to the Material table, specifying which materials are provided by which suppliers.

Field	Data Type
SupplierMaterialID	INT PRIMARY KEY
SupplierID	INT (Foreign Key)
MaterialID	INT (Foreign Key)

B. Appendix: Queries

Query 1: Identify Suppliers for Specific Material (ex:steel)

Finds all suppliers (SupplierName, SupplierID) that supply a material called 'steel'.

Retrieves additional information about the material (MaterialName, MaterialID).

It achieves this by joining three tables:

Supplier (providing supplier info),

SupplierMaterial (connecting suppliers and materials),

Material (providing material info).

This query is useful when you want to identify which suppliers can provide a specific material (in this case, steel)

Query 2: Tracking all deliveries made for a particular order(ex orderID: 31)

Query 3: provides valuable insights into the inventory status of various materials across different warehouse locations(facts from Inventory table)


```sql
SELECT
    I.InventoryID,
    M.MaterialID,
    M.MaterialName,
    I.QuantityOnHand,
    W.WarehouseName
FROM
    Inventory I
JOIN
    SupplierMaterial SM ON I.SupplierMaterialID = SM.SupplierMaterialID
JOIN
    Material M ON SM.MaterialID = M.MaterialID
JOIN
    Warehouse W ON I.WarehouseID = W.WarehouseID;
```

	InventoryID	MaterialID	MaterialName	QuantityOnHand	WarehouseName
1	31	1	Cement	100.00	Main Warehouse
2	32	2	Steel	200.00	Main Warehouse
3	33	3	Wood	150.00	Main Warehouse
4	42	12	Lumber	220.00	Main Warehouse
5	46	1	Cement	110.00	Main Warehouse
6	51	4	Glass	190.00	Main Warehouse
7	56	11	Insulation	150.00	Main Warehouse
8	61	1	Cement	130.00	Main Warehouse
9	34	4	Glass	300.00	East Warehouse
10	35	5	Paint	250.00	East Warehouse
11	43	2	Steel	160.00	East Warehouse
12	47	2	Steel	230.00	East Warehouse
13	52	7	Copper Wire	160.00	East Warehouse