

Construction Waste Minimization: Using Green Supply Chain Management

M Kranthi Kumar

*Department of Architecture,
School of Planning and Architecture, Vijayawada – 520008, India.*

Rajan D

*Department of Architecture,
School of Planning and Architecture, Vijayawada – 520008, India.*

Abstract- In the Indian economy, the Construction industry plays a major role in its growth and the same is accountable for environmental degradation. Hence there is a need for sustainability in all the construction activities. Green Supply Chain Management (GSCM) is considered as one of the main efforts, which aim to integrate environmental parameters within the supply of chain management. It helps to reduce waste produced in construction and to improve the environmental performances of the organizations. The objective of this research paper is to study about GSCM and its application in the Indian construction field. One of the causes of waste production (WP) in construction is the use of inappropriate material procurement methods (PM). Whilst adopting an appropriate method is considered to result in project success with less environmental impact, limited research has so far been conducted to empirically explore this relationship. Although a lot of studies have been done with a view to develop models/tools for aiding the selection process, there is less research on the influence on WP due to material procurement methods. The influence on WP due to material procurement methods is proved by both qualitative and empirical data collected. The paper concludes with a deep understanding of GSCM in India and also PM relationships with WP.

Keywords: Green Supply Chain Management, Procurement method, Environmental impact, Waste production.

I. INTRODUCTION

The fast phase construction activity in developing countries like India, there is a lot of environmental degradation and resource depletion. In this regard, there must be an utmost concern that needs to be provided to this which has given rise to the usage of Green supply chain management rather than traditional supply chain management. [6][2] The term “Supply chain” converts the basic material, products, or administration into completed products/projects using the series of linked organizations. All construction companies, be they clients, main contractors, designers, surveyors, sub-contractors, or suppliers are therefore part of a supply chain. The members of the different supply chain on different projects depends on the project type, nature of construction, and the procurement operation in the chain. Management of this supply chain has many potential benefits such as the reduction in project cost, minimization in waste produced, time reduction in construction without quality compromise which leads to a successful project with satisfied customers. [18]. Supply chain management is defined as the management of the flow of goods and services. When there is environmental thinking involved in the supply chain management it is termed as “Green supply chain management” Supply chain end customer’s requirements are provided by interconnected channels and node business which also involves the provision of products and services. Area of operation management and logistics are drawn heavily by supply chain management therefore there is a requirement for an integrated approach. The economic growth is directly proportional to energy consumed as well as material consumption, which indirectly escalates environmental issues and depletion of resources problems. In the current scenario, many firms face a competitive ambiance to provide a balance with economic and environmental aspects. To maintain this environmental integrity, every firm has to make better communication with suppliers to ensure the product is made with environmentally friendly materials which also helps suppliers to change the working method and material enhancement. [6]

II. OBJECTIVES

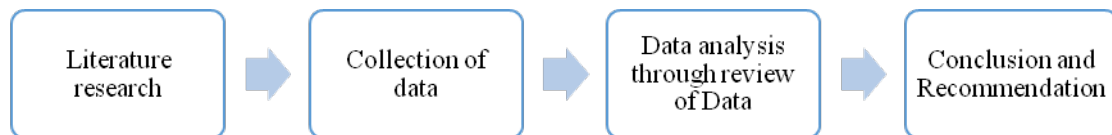
- To study about green supply chain management, benefits, and its application proposals in the Indian construction industry
- To study material procurement methods, measure for waste minimization, and find an efficient material procurement method that can be used
- To study about Integrating Green Construction to Green Supply Chain Management

III. METHODOLOGY

Through literature sources, the data regarding the green supply chain management, Material procurement methods, and Integration of Green construction into green supply chain management are collected. This paper is an integrated literature review approach which compiles the data from the literature source to conclude the construction waste minimization possibilities using the green supply management. This approach gives an apprehend green supply chain management role for waste minimization in the construction industry using certain methods like efficient material procurement approach for all building types and integration of Green construction and GSCM for sustainable building.

Figure 1. Methodology

A literature review requires detailed data collection related to the topic. The online database and technical paper help



in acquiring the required data. The data collection is made through approximately 20 research papers related to GSCM that tell about the procurement method and integration of Green construction and GSCM. The collected data are reviewed and summarized in the discussion. From the Literature data review, the conclusions and recommendations are made for the improvement that is needed in the near future related to GSCM role in construction waste minimization.

IV. LITERATURE REVIEW

A. Green supply chain -

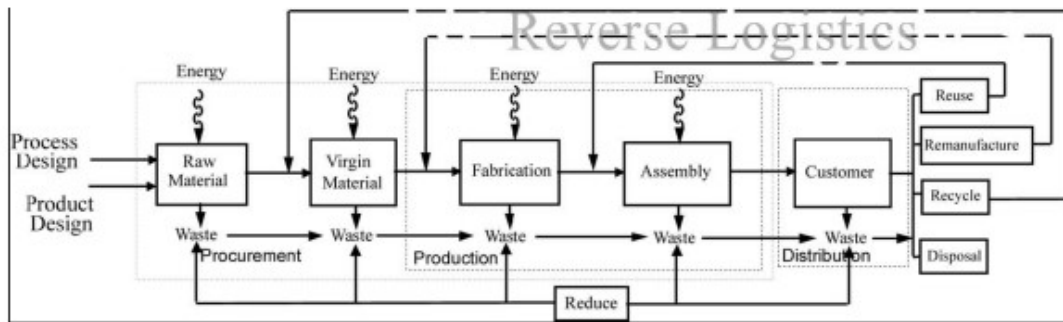
The definition for GSCM according to the construction industry is not available in most research papers. A most research paper focused on SCM secondary concepts. E.g. definitions of the following “Lean construction, Sustainability material management, Waste management, Reverse logistics, Environmentally friendly production, and management” [17][19]. There are very few authors that have defined the GSCM in construction and the following is one among them

“GSCM in construction lies under the dimensions like performance while in operation, cost-saving and efficient it is, and no harm to the environment”. And also, GSCM is mentioned as process integration for a stakeholder value up-gradation between suppliers and clients. [17]

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Different authors have a different vision for the GSCM objective and the same are listed below [5][17] [19] [6]

- Popular image and advantage to an organization
- Stakeholder value addition
- Supply chain improvement



Source: Opportunities in green supply chain management [10]

Figure 2. A supply chain with environmental influence practice

- Sustainability enhancement
- Hike in market share with better services
- Efficiency in waste, cost, and risk
- Reduction in environmental harm
- For social consideration

One of the missing factors in the objective is the role of long-term vision. i.e. All the research papers are more of conceptual objectives and explanation. There is a lack of practical live case study integrating the GSCM concepts in construction are explained. [17]

B. GSCM Role in various phases of construction -

To explain the role of GSCM in various phases of construction. GSCM is defined as the sum of the Green design, Green procurement of material, environmentally friendly manufacturing, Distribution, and marketing sustainably". Each phase is clearly explained in the following [5]

1) Green design

This allows the product to be functioning normally with more efficiency without creating a harmful effect on the environment. It doesn't require any resources this is all about the thought process of how to manufacture a product with very less or no environmental impact. The thought process includes the selection of material, Energy management, Procurement management of the product. When designing the product/projects some important factors need to be considered are mentioned below [6][8]

- Environmental design,
- Ecological way of design
- Life cycle design.

There are other factors also that also need to include in green designing are as follows [6][8]

- Organization management
- Top committee management
- Energy consumption reduction
- Claim and reuse
- Ecological management
- Government rules and regulations
- Disposal and remanufacturing
- Reverse logistics function.

2) Green procurement of material

Green procurement of material management includes 3R's concept in its process i.e. Reuse, Recycle, and Reduction. For material management in green procurement, some processes need to be carried out that include selection and separation of materials, material recovery. [6][16]

3) *Environmentally friendly manufacturing*

The energy consumed in conventional manufacturing is high and this manufacturing process is not very safe to surroundings. There are lots of internal and external factors in the production of the material. The factors of environmentally friendly production are Energy utilized, Amount of Resources spent, Hazardous waste reusability, Hazardous waste amount, Degree of green energy.[6][16][9]

4) *Distribution and marketing sustainably*

Marketing sustainability is the marketing of sustainable products only. Thus, this marketing will be different from the conventional one which includes activities like modification in the product, Changes in the manufacturing process, different packaging which includes optimum packaging for the product, and also different advertising. In green marketing, the responsibility of social cause plays a major factor in promoting the product. There are direct effects and indirect effects in marketing in which the public image of corporate plays a direct effect whereas social responsibility is the indirect effect on intention of purchase in the market.[6][16][9]

C. *GSCM in India-*

Providing the sustainability to the products-Process, system, and technology is defined as the green supply chain management. It's understood that the reduction of negative environmental impact is the ultimate goal rather than a passive approach to minimize waste or pollution. Then it will no different than the traditional solutions. So, there is a necessity for a better understanding of the implementation of GSCM in developing countries like India. This is a completely new concept in India and it needs deeper understanding to achieve its full benefits. People have started initiating in a developing country so this paper will aid them in better knowledge to know its advantages. [14]

Due to pandemic situations like COVID-19, the investors started moving its plant all over the world so India has become an attractive place for the industry growth because of its valuable resources. Due to a lot of new industries, the environmental impact due to construction activity multiplies which affects the environment around that area if there is no proper care taken.

In India, B.L. Lakshmi Meera and Dr. Palanisamy had made a clear statement that the current scenario has created a complex for many stakeholders like managers, academics, and researchers. GSCM consideration makes the organization with potential source & advantage over other companies rather than a cost-cutting method. In the present scenario, there is a compulsion for adopting GSCM for cost-cutting, risk reduction, Good savings, and revenue with a good public image. Adopting this makes the organizations going beyond the cost-cutting and increased efficiency for taking the strategy to be lean and clean for really green.[3][14]

D. *Indian Construction industry areas - Green supply chain management application proposals*

1) *Green supply chain design*

For the successful operation of the project, the green supply chain is important and indispensable. Each company has different supply chain design and different product needs different design to suit their needs. So, on the whole, it is divided into 2 types. [19]

1. Functional product - Less profit margin and demand are stable
2. Innovative product - High-profit margin and demand is not stable

The construction industry is considered a functional product. To improve the profit margin of the company we should improve the current product and management mode, Customer psychology adoption, existing procurement method need to be improved. The process of supply chain design for green products are listed below

- Market analysis.
- Additional features to enhance the experimentation and development trends.

Some of the main issues that need to be addressed are the composition of the supply chain members like site engineer, supplier, and other stakeholders, Raw material source, production planning, IT management, Procurement, and logistics management. Once the Green supply chain design is completed it needs to be verified using various techniques. [19]

2) *The Process involved in Construction Green Supply Chain*

The operation model process of the fully integrated construction industry is shown below

- Environmentally friendly Procurement policy and practice will decrease the harm to the surroundings and brings economic benefits. Green supply chain design should consider some of the aspects as follows:

Ensure the manufacturing process is clean and it can save energy, Proper usage of materials and waste mitigation, Establishment of proper communication between suppliers, Consideration of supplier attitude towards waste mitigation. [19]

- Green supply chain production not only includes the construction process but also included various processes from engineering construction design like the selection of materials Decoration and logistics design, Green design. Green design is simply the complete life cycle based on sustainable development. 3R has mentioned in the swatch Bharath manual (Reduce, Reuse, Recycle) need to be deployed in the production stage so that benefits cost savings, Energy consumption can be achieved. [19][6]
- The delivery process from the supplier to construction site/core Corporation includes significant six elements: Transportation of material, material management, the process of circulation, packaging, and data handling. Some of the non-green factor analysis states that decipher the supply and distribution system, transport planning, develop ability and reputation by building storage system are significant for the implementation of the green supply chain, so the choice should be given to the corporation for choosing the green supply chain links and so that there is an enhancement in the image of the corporation. [19]
- In the current scenario, the Indian Construction industry produces 30% to 40% of municipal waste. [19] All the waste is transported to rural areas and left behind without any processing in an open area. This way of disposing of causes heavy environmental damage. Some of the important organizations, laws, and orders are actively involved in environmental protection due to construction waste. So it is important to spread awareness of how to discharge construction waste. Green supply chain recovery includes some major areas: waste reclamation, recovery with payment, or free of charge. The optimum plan needs to be used during the process of a green supply chain design. The plan includes Recovery materials sales, Selection of plan based on cost-benefit analysis, Scrap treatment, Mechanical treatment which has no environmental pollution. [19][9]

E. Benefits

Even though it requires more intelligence and a lot of resources deployed than traditional SCM it has more gain in all accepts for completed and ongoing times of projects. It doesn't satisfy the only individual rather it's more beneficial to the surrounding environment also. Adopting this can be found a little hard during its earlier time of usage later the organization which adopts will make this as one of the primary rules in all construction.

1) Cost savings with efficiency:

Reduction in waste and efficient usage of resources leads to saving in cost. There is a considerable amount of savings due to its usage in organizations. Public image enhancement among others in the market. [12][6]

2) Product standard enhancement

Due to this shift, a partnership between the supplier and contractor develops which helps the contractor to take command over the design and quality. [12]

3) Improved status among other stakeholders

Improved sustainability clause improved the organization's fame among others in this competitive market. [12]

4) Sustainability goal

In today's world, it becomes the organization job to sort out the environmental goals so that supplier fulfills and see the benefits achieved. [12]

5) Innovation advantage

Savings can be attained through proper production management which is through cleaner technology, Invention, and waste minimization. Every sqft of reduction in waste is money that is less spent. [12][6]

F. Procurement-

From the starting stage of the preparation and processing of the appropriation for obtaining goods and services till receipt and approval of the invoice for the payment, these are highly bound to supply chain management. This process is called procurement. Purchase is nothing more like getting things required by an organization. This is the starting point for preparation that is getting a purchase order and initiating the process. Procurement has wide extensive meaning than purchasing like identifying the type of work involved, supplier selection and their performance, Material management, promoting, checking orders, and others. The objective of procurement is to

provide the correct amount of the right product at the required time with the wholesale cost. So, it is defined as the acquirement of goods or services. [15]

Love et al (2007) described construction procurement as “An organizational structure that arranges specific responsibilities and authorities to participants and defined the relationship of the various elements in the construction projects”

Some of the key features in procurement are noted down and listed below [16]

- Waste reduction commitment with suppliers
- Purchase management
- Delivery management inefficiently
- BOQ in a waste efficient way

Table 1: Waste reduction through measures in material procurement

S.no	Significant feature	Waste reduction through measures in material procurement
1	Supplier's job commitment	Delivering whatever the quantity maybe
		Take back scheme commitment
		Durable and quality products
		Optimum packaging
2	Material purchase management	Usage of waste efficient material and technology
		Usage of recyclable material
		Purchase quality material
		Don't have a deviation in order
		Appropriate purchase
3	Delivering effectively	Good guard to material
		Ease access to the site
		Efficient scheduling in delivery
		Pull system adoption (JIT)
4	Efficient BOQ	Correct ordering
		Waste allowance should be provided
		The optimum amount is ordered

Source: Optimizing material procurement for construction waste minimization: An exploration of success factors [16]

Some of the common driving factors that produce wastes during procurement are listed below [9]

- Hierarchy in organization
- Administration
- Info sharing
- Duration of process
- Involvement of the client and various stakeholders
- Process of tendering
- Mode of payment
- Creative thinking (i.e.value management, Information regarding technology)
- Contract type and document
- Bonding between stakeholders.

G. Waste management through material procurement methods-

Management of waste through material procurement is classified into 4 categories from the literature study and those are

- Job commitment by the supplier
- Management of material purchase
- Delivery management of material efficiently
- BOQ with efficient management of waste. [16]

These are explained in detail below

1) Job commitment by the supplier

Two things are done from their side.

- Desire to supply in small quantities.
- To take the excess material off for the resale.

2) *Management of material purchase with the low waste motto*

The success rate of any project depends on how well the management of material purchase is maintained as material alone will cost around 50% of construction cost, so it is very important to manage the material flow properly in the project which leads to a reduction in waste produced. [16] The wrong order placement due to some kind of unique construction activities needs to be sorted out before placing actual material order to avoid wastage. "The deciding step like material purchase needs to take care with the utmost concern as it is one of the major factors contributing to waste production in construction. Waste prevention methods are needed to be considered during the process" [16]. The use of the pre-constructed material in the procurement process leads to the reduction of waste in the site. There should be sufficient considerations taken while choosing the nature of the material. Thus, usage of low-quality materials always leads to frequent restoration which causes more wastage than usual.

An author has mentioned that "There is no usage if the material is put for recycling if there is a chance of moving it forward to other projects the motto of saving the environment and reduction in waste is misused here". [16]

3) *Delivery management of material efficiently*

There are two systems in supply chain management. (a) Push system (b) Pull system

Push system: This system requires quite a large space because in this type of system the total required material is calculated beforehand and overstocked on site so that there is no shortage of material occurs. This system has a drawback of producing a large amount of waste than the pull system. [16]

Pull system: This system is also called Just in the delivery system and it is a very efficient way of delivering material with very little in waste production. It has been said even though there is a reduction of the cost when orders are made in bulk yet there will be a large number of waste produced which equals the amount spent when you get things in small quantity which produces very less amount of waste as compared to bulk booking. Herby, this system takes the material to the site only when there is a requirement that prevents wastage of material during delivery. [10]

4) *BOQ with efficient management of waste.*

When calculating the material required in Bill of quantity (BOQ) there should sufficient waste allowance need to provide so that ordered material is destitute of over/under ordering. The waste allowance provided is 2.5% - 10% nothing more or less each material differs according to that allowance differ. [16]

H. *Green building design to GSCM integration*

The reduction of the raw material that is used in the structure body is considered as the way to obtain waste management goals using GSCM. Equity between the strength and the number of materials is hard and usually different for different materials. A new type of material that is used as secondary material is way lighter and durable, recyclable so that they are connected to GSCM. This reduction and reusability of material contribution to the GSCM. Adopting this not only reduce waste but also recoverable and saves energy if the Green material is used instead of conventional ones. Implementation of GSCM and green building design needs to be done in the design phase so that integration can be very well planned without any discrepancies. Both the GSCM and green buildings have economic and social benefits. The lifecycle time of the project is considered green due to the adoption of GSCM in green building design once after its demolition also the material that is demolished can be used as raw material for manufacturing some other material. The whole measures that are mentioned above for procurement methods and waste reduction will help to get the material more with savings in energy and cost savings. [7][8]

V. DISCUSSION

A. *GSCM and Construction waste mitigation process-*

Green Supply Chain Management as perceived from the above data improves the traditional supply chain solutions like (a) Improvement in activity as it mitigates the dangers and also, subsequently enlarges up innovations. (b) Advancing calibration as green supply chain administrates deals in arranging strategies with suppliers furthermore, clients who thusly lead to the better arrangement of association cycles and standards. (c) Increased versatility as a green supply chain fasten prompts inventive cycles and consistent improvements. The green supply chain takes one more step further than traditional by providing more value to the project by adding more to it through the thinking process of environmental impact consideration.

Sustainability is a significant thought to supply chain management and it is through practicing environmental awareness idea that organizations gain acknowledgment in serious worldwide business sectors. Most organizations are as yet battling with acquiring certain predictable information to gauge value chain viability and ecological duty because these days the worth is been made in a supply chain that issues most in supply chain management. Awareness among customers and expanded, proper guidelines will put added requests on companies to drive green design & manufacturing activities so that the supply chain is efficient as customers approach a great deal of data and comprehend the effects of sustainable activities. Associations acquire sustainability through green supply chain management rehearses that get woven into the core strategies of organizations and, public division associations. After organizations gain inspiration and begin starting this green system, supply chain managers need to underscore on the accompanying three most urgent perspectives:

Usage of Greener materials and packaging to reduce waste during construction and increase recyclability during deconstruction.

- Acquiescence in supply chain networks.
- Something that is very most important i.e. Reverse logistics provided from the manufacturer end.

The GSCM is considered as one of the cost-cutting methods in India rather than knowing its benefits. Some of the important benefits that need to be highlighted are other than cost-cutting is Company image enhancement, increased innovation activity, and greener solutions to all problems. Two products have been discussed in which the functional product in supply chain management has more opted in the construction industry. Some of the significant processes that need to be considered are Environmental-friendly procurement policy has been used, Steps need to be taken care of in engineering design, the delivery process needs to be administrated, Mitigation of waste is just as it ends up in landfill at the end of the day. In the current scenario, the supply chain is in the role of all large-scale projects soon there will be a need of shifting to green supply chain management as the whole world is moving to sustainability so this part of knowledge aids in awareness about its usage. Once after seeing its value and financial benefits in a long-term vision every client demands its need for the projects. As the safety of the building is considered as no choice in the building in near future the policies need to be implemented in such a way that every large-scale project needs to adopt a sustainable goal in their projects.

GSCM comprises of the following stages, in brief, starting from the Thinking of design in an environmentally friendly manner, Material logistics and production in an eco-friendly way, Marketing and distribution in a sustainable manner, and end of life to happen in an eco-friendly way without creating the negative impact.

B. Material Procurement – Waste mitigation-

Material procurement is the part of GSCM, this defines how efficiently the material is produced/manufactured and delivered. There are different types of material procurement ways that need to be considered. The supplier who has been selected should have an attitude towards a waste reduction. Manufacture needs to have a take back scheme with the material if it is not used so that the same material can be recycled before ending up in the landfill. The contractors selected for the execution should have a low waste motto so it doesn't add up a new burden as they are always considered. The system through which the material is delivered is a pull and push system. (JIT) This JIT (Just in time) system is considered one of the good systems that reduce the waste that is produced in the delivery process. Usage of this JIT system avoids overstocking and this requirement time delivery process reduces the waste. Optimum packaging needs to be provided nothing more or less. One of the major things that need to be taken care of before ordering the material is the proper estimation of the materials. The provision of waste needs to be added and estimated. The same should not be more than 5% of the required quantity.

C. The amalgamation of GSCM and Green building design-

The integration of GSCM in green building design is an additional point that is obtained due to its environmental consideration in the material procurement process. It creates innovative methods that make the building more added value. The GSCM integration is fully successful if it has been thought of in the design stage and not in the construction stage. Amalgamation provides a much broader scope than the traditional one. In the deconstruction stage also the materials from this kind of designed building have more value in the market than the traditional ones. Due to this amalgamation in design, the construction firm will have the option to limit the expense while making benefit from their waste, and the most significant it will be ecologically well disposed and less destructive for the human wellbeing.

VI. CONCLUSION AND RECOMMENDATION

GSCM is considered one of the recent trends in the construction industry and some are practicing without its proper knowledge. Even though the supply chain management practice has been there in India for many more years, this concept of environmental consideration in supply chain management which is called GSCM has been in play for the past few years only and it didn't reach enough to all stakeholders. In a developing country like India, the GSCM is practiced as a cost-cutting method rather than obtaining its long-term goals. GSCM role in the construction industry defines that it has to be initiated from the start of the design phase, proceeded in the constructed phase, and gets concluded in the deconstruction phase of the building. Inclusion of the sustainability concepts to the project-Process, system, and technology is defined as green supply chain management. It has more benefits like innovation advantage, sustainability goals, etc. than traditional supply chain management. The application process explains how the management needs to be done in its design and process operation of construction. In design, the construction industry is been taken as a functional product very profit is less but demand is stable. In the process, the operation model of the integrated construction industry is sustainable policies. Involvement in the engineering design, Delivery method, and Reclamation of waste. In the future, the Role of GSCM in the construction industry using the live case study could fetch more reality and define its success rate.

Construction waste which has become one of the major issues in recent day and Mitigation of it is mandatory in recent times. Some major problems give rise to the production of construction waste in the procurement process are listed below (a) Required materials are miscalculated (b) Supplier with no sustainable motto (c) Excess amount of packaging for the shipping materials (d) Overstocking of materials (i.e. Delivery system management adopted). Delivery system management decides how the material is procured and in recent times there is a growth in usage of just in time delivery system due to its sustainability concept but again this largely depends on supplier attitude towards the sustainability also. From the listed problem it is very evident that the efficient material procurement method is one of the factors that need to be considered in the construction waste mitigation plan. In the future, the barriers to its implementation in India and factors that influence the waste generation can be discussed using a questionnaire survey with different stakeholders in the Indian construction industry.

The integration of GSCM and green building has many benefits over the conventional way of doing it separately. Consideration of its integration fetches more savings than usual. Some of its benefits are (a) more opportunity for involvement in learning raw material production method, (b) the possibilities of innovation are explored due to the involvement in the production stage, (c) due to the innovation there are possibilities for replacement of traditional materials which consumes more energy (d) Even the deconstruction phase of this type integrated building design fetches more value than conventional ones. From the benefits mentioned it is very clear that the integration of GSCM and green building design should be started in the design phase itself to obtain maximum benefits. In the future, the benefits of its integration can be more elaborately explained using the live case study in India

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