A Multi-Objective Planning Approach for Deconstruction Projects

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***Abstract*— This paper presents a multi-objective mixed-integer linear programming (MILP) model for project deconstruction planning, combining precedence-constrained task scheduling, workforce and shared-equipment allocation, material valorization, and material transportation. The model is solved by using the lexicographic technique and trade-offs between three objectives : profit, project duration, and material landfilling reduction. Preliminary results obtained based on a fictive instance confirm the feasibility of the formulation and show that the chosen priority order of the objectives can drastically change the solution, revealing strong tensions between economic performance and circularity outcomes.**

I. INTRODUCTION

Construction, Renovation and Demolition (CRD) activities are among the largest sources of waste in many regions [1]. This has increased interest in deconstruction, which consists mainly of carefully dismantling buildings to recover materials [2]. As a practical application of circular-economy principles, deconstruction differs from conventional demolition by focusing on material recovery for reuse and recycling [3]. This requires careful planning such as determining when materials should be removed, what quantities for each type of material, how they should be dismantled and where they should be sent. Therefore, project performance is not assessed only based on time or cost. It also depends on how well materials are recovered and how well on-site work is coordinated with recycling and reuse facilities.

This paper formulates a planning framework for a deconstruction projects over a discrete time horizon, combining (i) precedence-constrained task scheduling, (ii) workforce and shared-equipment allocation under limited capacity, and (iii) material treatment and outbound logistics decisions. The goal is to support decisions that both promote circular economy objectives, especially reducing landfill use, and maintain economic viability by balancing total costs and project duration.

In practice, planning such projects is difficult because deconstruction usually requires more time and labor than standard demolition, and because there is uncertainty about both the quantity and quality of materials that can actually be recovered during extraction. Storage choices, whether on-site or off-site, can increase costs and can even affect the project schedule [4]. This is why decision support tools are needed early, before waste is produced, and not only after waste has already been generated [5]. More generally, deconstruction is now widely seen as an important end of life strategy for circular construction, i.e. this sector has moved from demolition and waste management topics toward circular construction perspectives [6], [7].

Boukherroub et al. (2026) [8] review optimization approaches for deconstruction planning, including project scheduling, transportation planning, and reverse logistics network design. Their systematic review covers the period from 2000 to mid-2024 and retains 17 studies for detailed analysis. They highlight that most models focus on operational planning and on-site decisions, with limited coordination between on-site deconstruction and off-site logistics or recycling. Other reviews also note that logistics network optimization remains not strongly covered in circular construction research [9], [10].

When models integrate both on-site and off-site decisions, they typically combine choices such as deconstruction or demolition techniques, workforce and equipment sizing, container type and capacity decisions, recovery options, and the destination assignment of material streams. This integrated scope is illustrated in optimization frameworks for CRD reverse logistics [11], [12], and in multi-objective models that jointly consider project duration and cost, recovery indicators, and sometimes environmental impact [5]. In contrast, strategic decisions are rarely addressed. An exception is the strategic network design work of Schleier and Walther (2024) [13] on recycling systems for expanded polystyrene insulation waste, which combines long term technology and capacity decisions with operational flow allocation.

Across the literature, the most common objectives are to minimize project duration and project cost. Profit maximization is less frequent, partly because resale markets are uncertain and prices and demand are difficult to estimate. Several works therefore focus on cost minimization and results can vary across regions depending on standards and market support [14]. Environmental objectives are still less common, but some recent works incorporate life cycle assessment indicators and explore trade-offs between cost and environmental performance, sometimes using Building-Information-Modeling-based (BIM) based disassembly planning to generate input data and scenarios [15], [16]. Finally, Boukherroub et al. (2026) [8] stress several persistent gaps that motivate further research, including the absence of considering uncertainty on recovered quantities and quality, uncertainty on demand and prices, limited BIM integration

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for existing buildings, and the lack of standardized classification of recovered materials, which limits market development and decision support.

The remainder of this paper is organized as follows. Section II describes the deconstruction planning problem and its main assumptions. Section III details the proposed multi-objective MILP formulation. Section IV presents preliminary computational results on a fictive test instance and discusses the main trade-offs between profit, project duration, and landfilling reduction. Finally, Section V concludes the paper and outlines future research directions.

II. PROBLEM STATEMENT

We study the planning of a building deconstruction project where we assume that a prior diagnostic, coming from an expert, identifies a finite set of tasks. Each task has precedence constraints, requires labor as workers and possibly equipment as resources, and generates material flows to be recovered. The objective is to build a feasible schedule over a discrete time horizon while respecting task precedences.

Time is discretized into unit periods. Once started, a task must be completed without interruption over consecutive time periods, and assigned resources are fully used during each period. Workforce availability is limited in every period, and task duration depends on the number of workers assigned: more workers may reduce the duration, but it raises per-period labor demand and may violate workforce limitation constraint, leading to infeasibility. Tasks may also require shared resources that remain monopolized for the whole task duration, which restricts which tasks can run simultaneously.

Each task also involves a material recovery decision corresponding to a strategy among three possibilities (reuse, recycling and landfilling). A given combination of these strategies constitutes a recipe, which sets the processing mode and thus the task duration, and it also affects costs, logistics, and equipment needs. Recovered materials are temporarily stored on-site in containers with limited capacity and allocated to specific destinations. When containers are full, truck evacuations are required. Vehicle routing is not considered in our model, but number of trips and transportation costs are accounted for. Destinations also have limited intake capacities.

TABLE I
LIST OF SETS USED IN THE MODEL.

Set	Description
$\mathbf{A}$	Set of tasks in the deconstruction project
$\mathbf{P}_a \subseteq \mathbf{A}$	Subset of predecessor tasks that must be completed before task a is started
$\mathbf{K}_a$	Set of feasible recipes for task a
$\mathbf{W}_{ak}$	Set of feasible workforce levels for task a under recipe k
$\mathbf{T}$	Set of discrete unit time periods over the planning horizon
$\mathbf{S}$	Set of strategies (reuse, recycling, landfilling)
$\mathbf{M}$	Set of material types generated by tasks
$\mathbf{R}$	Set of shared on-site resources required by tasks
$\mathbf{D}$	Set of treatment destinations for material flows

TABLE II
LIST OF PARAMETERS OF THE MODEL.

Parameter	Description
$\mathbf{D_MODE}_{akw}$	Duration of task a when executed with recipe k and workforce level w
$\mathbf{LIM_WORKERS}_t$	Maximum number of workers available at time period t
$\mathbf{RES_REQUESTED}_{ark}$	Amount of shared resource r required by task a when performed with recipe k
$\mathbf{LIM_RESOURCES}_{rt}$	Maximum available amount of shared resource r at time period t
$\mathbf{QTY_MATERIAL}_{akms}$	Quantity of material m obtained with strategy s when task a is executed with recipe k
$\mathbf{IS_A_DEST}_{msd}$	Binary parameter equal to 1 if material m obtained with strategy s is sent to destination d, and 0 otherwise
$\mathbf{LIM_CONTAINER}_d$	Container capacity associated to destination d
$\mathbf{LIM_DEST}_d$	Maximum total quantity that destination d can receive over the project duration
$\mathbf{COST_W_UNIT}$	Labor cost per worker per time period
$\mathbf{COST_R_UNIT}_r$	Cost of using resource r per time period
$\mathbf{COST_TREATMENT}_{ms}$	Treatment cost per tonne of material m obtained with strategy s
$\mathbf{COST_TRIPS_UNIT}_d$	Transport cost per trip with destination d
$\mathbf{REVENUE_UNIT}_{ms}$	Revenue per tonne of material m obtained with strategy s
$\mathbf{M_T}$	big-M set to $\lvert\mathbf{T}\rvert - 1$
$\mathbf{M_W}_a$	big-M for task a, set to $\max_{k\in\mathbf{K}_a,\, w\in\mathbf{W}_{ak}} w$

III. MATHEMATICAL MODEL

We formulate the project deconstruction planning problem as a multi-objective Mixed-Integer Linear Program (MILP), which jointly captures (i) precedence-constrained task scheduling over a discrete time horizon, (ii) workforce and shared-equipment allocation subject to limits, and (iii) material recovery choices and outbound logistics regarding treatment destinations. The model is defined in the following subsections by specifying the sets, parameters, decision variables, constraints, economics calculations, and objective functions.

A. Constraints

$$\sum_{t\in\mathbf{T}} \mathrm{TASK_IS_ACTIVE}_{at} = 1 \qquad \forall a \in \mathbf{A} \tag{1}$$

$$\sum_{k\in\mathbf{K}_a} \sum_{w\in\mathbf{W}_{ak}} \mathrm{MODE}_{akw} = 1 \qquad \forall a \in \mathbf{A} \tag{2}$$

$$\mathrm{DURATION}_a = \sum_{k\in\mathbf{K}_a} \sum_{w\in\mathbf{W}_{ak}} \mathrm{D_MODE}_{akw} \cdot \mathrm{MODE}_{akw} \;\forall a \in \mathbf{A} \tag{3}$$

$$\mathrm{START}_a = \sum_{t\in\mathbf{T}} t \cdot \mathrm{TASK_IS_ACTIVE}_{at} \qquad \forall a \in \mathbf{A} \tag{4}$$

$$\mathrm{END}_a = \mathrm{START}_a + \mathrm{DURATION}_a \qquad \forall a \in \mathbf{A} \tag{5}$$

TABLE III

LIST OF DECISIONS VARIABLES.

Variable	Description
$\mathbf{MODE}_{akw}$	Binary variable equals 1 if task a is executed with recipe k and workforce level w
$\mathbf{TASK_IS_ACTIVE}_{at}$	Binary variable equals 1 if task a starts at time period t
$\mathbf{TASK_IS_RUNNING}_{at}$	Binary variable equals 1 if task a is being performed during time period t
$\mathbf{RECIPE}_{ak}$	Binary variable equals 1 if recipe k is selected for task a
$\mathbf{DURATION}_{a}$	Duration of task a
$\mathbf{START}_{a}$	Start period of task a
$\mathbf{END}_{a}$	End period of task a
$\mathbf{MAKESPAN}$	Overall project completion time
$\mathbf{NB_WORKERS}_{a}$	Workforce level assigned to task a
$\mathbf{NB_W_PERIOD}_{at}$	Number of workers assigned to task a during time period t
$\mathbf{NB_RES_USED}_{rt}$	Total amount of shared resource r used during time period t
$\mathbf{FLOW}_{ams}$	Quantity of material m generated by task a and associated with strategy s
$\mathbf{QTY_DEST}_{d}$	Total quantity of materials sent to destination d
$\mathbf{NB_TRIPS}_{d}$	Number of trips required to transport the quantity of materials assigned to destination d
$\mathbf{RECIPE_RUN}_{akt}$	Auxiliary binary variable used to linearize the conjunction of recipe selection and task execution at time period t

$$\mathrm{START}_a \geq \mathrm{END}_{a'} \qquad \forall a \in \mathbf{A},\ \forall a' \in \mathbf{P}_a \tag{6}$$

$$\mathrm{MAKESPAN} \geq \mathrm{END}_a \qquad \forall a \in \mathbf{A} \tag{7}$$

$$t \geq \mathrm{START}_a - \mathrm{M_T} \cdot (1 - \mathrm{TASK_IS_RUNNING}_{at})\ \ \forall a \in \mathbf{A}, \forall t \in \mathbf{T} \tag{8}$$

$$t+1 \leq \mathrm{END}_a + \mathrm{M_T} \cdot (1 - \mathrm{TASK_IS_RUNNING}_{at})\ \forall a \in \mathbf{A}, \forall t \in \mathbf{T} \tag{9}$$

$$\sum_{t \in \mathbf{T}} \mathrm{TASK_IS_RUNNING}_{at} = \mathrm{DURATION}_a \qquad \forall a \in \mathbf{A} \tag{10}$$

$$\mathrm{NB_WORKERS}_a = \sum_{k \in \mathbf{K}_a} \sum_{w \in \mathbf{W}_{ak}} w \cdot \mathrm{MODE}_{akw} \qquad \forall a \in \mathbf{A} \tag{11}$$

$$0 \leq \mathrm{NB_W_PERIOD}_{at} \leq \mathrm{M_W}_a \cdot \mathrm{TASK_IS_RUNNING}_{at}\ \forall a \in \mathbf{A}, \forall t \in \mathbf{T} \tag{12}$$

$$\mathrm{NB_W_PERIOD}_{at} \leq \mathrm{NB_WORKERS}_a \qquad \forall a \in \mathbf{A},\ \forall t \in \mathbf{T} \tag{13}$$

$$\mathrm{NB_W_PERIOD}_{at} \geq \mathrm{NB_WORKERS}_a - \mathrm{M_W}_a \times (1 - \mathrm{TASK_IS_RUNNING}_{at}) \qquad \forall a \in \mathbf{A},\ \forall t \in \mathbf{T} \tag{14}$$

$$\sum_{a \in \mathbf{A}} \mathrm{NB_W_PERIOD}_{at} \leq \mathrm{LIM_WORKERS}_t \qquad \forall t \in \mathbf{T} \tag{15}$$

$$\mathrm{RECIPE}_{ak} = \sum_{w \in \mathbf{W}_{ak}} \mathrm{MODE}_{akw} \qquad \forall a \in \mathbf{A},\ \forall k \in \mathbf{K}_a \tag{16}$$

$$\mathrm{RECIPE_RUN}_{akt} \leq \mathrm{RECIPE}_{ak}\ \forall a \in \mathbf{A},\ \forall k \in \mathbf{K}_a,\ \forall t \in \mathbf{T} \tag{17}$$

$$\mathrm{RECIPE_RUN}_{akt} \leq \mathrm{TASK_IS_RUNNING}_{at}\ \forall a \in \mathbf{A},\ \forall k \in \mathbf{K}_a,\ \forall t \in \mathbf{T} \tag{18}$$

$$\mathrm{RECIPE_RUN}_{akt} \geq \mathrm{RECIPE}_{ak} + \mathrm{TASK_IS_RUNNING}_{at} - 1 \quad \forall a \in \mathbf{A},\ \forall k \in \mathbf{K}_a,\ \forall t \in \mathbf{T} \tag{19}$$

$$\mathrm{NB_RES_USED}_{rt} = \sum_{a \in \mathbf{A}} \sum_{k \in \mathbf{K}_a} \mathrm{RES_REQUESTED}_{ark} \times \mathrm{RECIPE_RUN}_{akt} \qquad \forall r \in \mathbf{R},\ \forall t \in \mathbf{T} \tag{20}$$

$$\mathrm{NB_RES_USED}_{rt} \leq \mathrm{LIM_RESSOURCES}_{rt} \qquad \forall r \in \mathbf{R},\ \forall t \in \mathbf{T} \tag{21}$$

$$\mathrm{FLOW}_{ams} = \sum_{k \in \mathbf{K}_a} \mathrm{QTY_MATERIAL}_{akms} \cdot \mathrm{RECIPE}_{ak} \quad \forall a \in \mathbf{A},\ \forall m \in \mathbf{M},\ \forall s \in \mathbf{S} \tag{22}$$

$$\mathrm{QTY_DEST}_d = \sum_{a \in \mathbf{A}} \sum_{m \in \mathbf{M}} \sum_{s \in \mathbf{S}} \mathrm{IS_A_DEST}_{msd} \cdot \mathrm{FLOW}_{ams}\ \forall d \in \mathbf{D} \tag{23}$$

$$\mathrm{QTY_DEST}_d \leq \mathrm{LIM_CONTAINER}_d \cdot \mathrm{NB_TRIPS}_d \qquad \forall d \in \mathbf{D} \tag{24}$$

$$\mathrm{QTY_DEST}_d \leq \mathrm{LIM_DEST}_d \qquad \forall d \in \mathbf{D} \tag{25}$$

Each task is executed exactly once (1). Exactly one recipe and one workforce level are chosen per task (2), and they fix the task duration (3). Start and end times are derived from the chosen start time period and the duration (4)–(5). A task can start only after all its predecessors are completed (6). The makespan is the time at which all tasks are completed, therefore it must be equal or greater than the end time of each task (7). A task can be performed only inside its execution window (8)–(10). The number of workers assigned to each task is derived from the selected recipe and workforce level (11). The total workforce used in each period cannot exceed a certain limit (12)–(15). The auxiliary variable RECIPE_RUN is activated only when the corresponding recipe is selected and the task is being performed (16)–(19). Periodic resource usage is aggregated from recipes being applied and cannot exceed a certain limit (20)–(21). Material flows depend on the selected recipe (22). The total quantity of materials sent to a given destination represent the total material flows obtained from all tasks and shiped to that destination (23). The number of trips required to supply to each destination is determined by the container capacity (24), and the delivered quantity cannot exceed the destination intake capacity (25).

B. Economics terms calculations

$$\mathrm{COST_WORKERS} = \sum_{a \in \mathbf{A}} \sum_{t \in \mathbf{T}} \mathrm{NB_WORKERS_PERIOD}_{at} \cdot \mathrm{COST_W_UNIT} \tag{26}$$

$$\mathrm{COST_RESOURCES} = \sum_{r \in \mathbf{R}} \sum_{t \in \mathbf{T}} \mathrm{NB_RES_USED}_{rt} \cdot \mathrm{COST_R_UNIT}_r \tag{27}$$

$$\mathrm{COST_TREATMENT} = \sum_{a \in \mathbf{A}} \sum_{m \in \mathbf{M}} \sum_{s \in \mathbf{S}} \mathrm{FLOW}_{ams} \cdot \mathrm{COST_TREATMENT_UNIT}_{ms} \tag{28}$$

$$\mathrm{COST_TRANSPORT} = \sum_{d \in \mathbf{D}} \mathrm{NB_TRIPS}_d \cdot \mathrm{COST_TRIPS_UNIT}_d \tag{29}$$

$$\mathrm{REVENUES} = \sum_{a \in \mathbf{A}} \sum_{m \in \mathbf{M}} \sum_{s \in \mathbf{S}} \mathrm{FLOW}_{ams} \cdot \mathrm{REVENUE_UNIT}_{ms} \tag{30}$$

The economic evaluation of a deconstruction plan relies on four cost terms and one revenue term. Labor cost represents the total labor expense induced by the number of workers mobilized over time (26). Resource cost represents the usage of shared on-site equipment, aggregated over the planning horizon (27). Treatment cost reflects the fees paid to process recovered materials following each strategy (reuse, recycling, landfilling), depending on the material type (28). Transport cost represents the fees paid to ship the total quantity of

materials to the selected destinations, considering all trips required (29). Revenues represent the income from recovered materials related to reuse and recycling (30). Thus, the overall profit of the plan is defined as:

$$\begin{aligned}&\text{PROFIT} = \\ &\text{REVENUES} - \text{COST_WORKERS} - \text{COST_RESOURCES} \\ &-\text{COST_TREATMENT} - \text{COST_TRANSPORT}\end{aligned} \tag{31}$$

C. Objective functions

The model is designed to support decision making from complementary perspectives. First, an economic objective evaluates whether the deconstruction plan is profitable once all costs are balanced against revenues from recovered materials (32). Second, a time-based objective captures the operational need to complete the project as fast as possible (33). Third, a circularity-oriented objective emphasizes material valorization by reducing the quantity sent to landfills, which indirectly promotes reuse and recycling (34).

$$Z_1 = \max \ \text{PROFIT} \tag{32}$$

$$Z_2 = \min \ \text{MAKESPAN} \tag{33}$$

$$Z_3 = \min \sum_{a \in \mathbf{A}} \sum_{m \in \mathbf{M}} \text{FLOW}_{am\{\text{Landfill}\}} \tag{34}$$

IV. PRELIMINARY RESULTS AND DISCUSSION

A. Numerical results

The test instance is fictive and represents a deconstruction project composed of 7 tasks over a discrete planning horizon of 37 possible time periods equivalent to working days. The construction site generates a total of 70.9 tonnes of materials. The model includes 3 strategies (reuse, recycling, landfilling), 9 material types, 9 shared resources, and 9 treatment destinations (2 for reuse, 6 for recycling, and 1 for landfill). Each task can be executed following 3 alternative recipes, with task-dependent feasible workforce levels, which jointly determine task duration, resource requirements, and material allocation.

The precedence structure is representative of real deconstruction project where task 1 (interior stripping) precedes tasks 2 (external carpentry) and 3 (electrical and water systems), which must both be completed before task 4 (roof removal). Task 4 precedes tasks 5 and 6 (upper and ground floor structural works), and finally the project ends with task 7 (foundations and final cleaning), which depends on both tasks 5 and 6.

The multi-objective model was solved based on the fictive instance with a lexicographic approach. This means that the objectives are optimized one after another in a fixed priority order. By doing this, the priority order is strictly respected and any improvements on lower-priority objectives can never deteriorate higher-priority ones. Material quantities are expressed in tonnes, and the monetary units (costs, revenues, and profit) are expressed in euros.

We tested the approach under six different priority orders, which we refer to as scenarios. For each scenario, we report 5 key performance indicators in addition to the 3 objective function values.

Scenario 1 : Z_1, Z_2 and Z_3

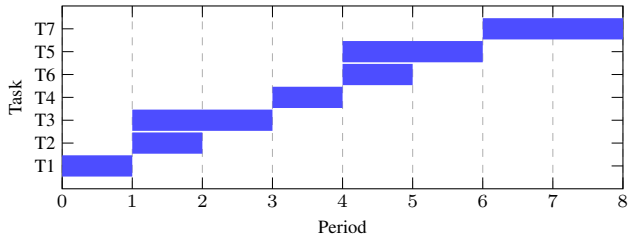

Fig. 1. Gantt Schedule of Scenario 1

TABLE IV
ECONOMIC AND ENVIRONMENTAL RESULTS OF SCENARIO 1

Indicator	Value
Profit of the project	1,939.5 €
Revenue	29,222.7 €
Cost of workers	15,040 €
Cost of resources	1,170 €
Cost of treatment	7,633.2 €
Cost of transport	3,440 €
Materials sent to landfill	56.65 t

Scenario 2 : Z_1, Z_3 and Z_2

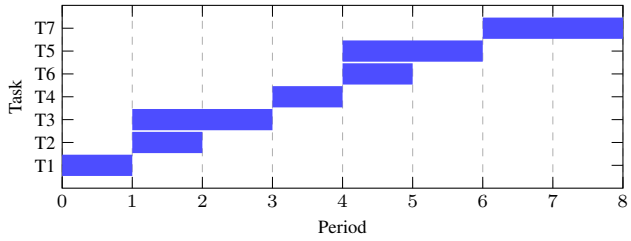

Fig. 2. Gantt Schedule of Scenario 2

TABLE V
ECONOMIC AND ENVIRONMENTAL RESULTS OF SCENARIO 2

Indicator	Value
Profit of the project	1,939.5 €
Revenue	29,222.7 €
Cost of workers	15,040 €
Cost of resources	1,170 €
Cost of treatment	7,633.2 €
Cost of transport	3,440 €
Materials sent to landfill	56.65 t

Scenario 3 : Z_2, Z_1 and Z_3

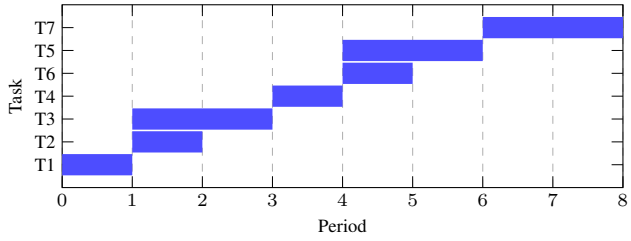

Fig. 3. Gantt Schedule of Scenario 3

TABLE VI

ECONOMIC AND ENVIRONMENTAL RESULTS OF SCENARIO 3

Indicator	Value
Profit of the project	1,939.5 €
Revenue	29,222.7 €
Cost of workers	15,040 €
Cost of resources	1,170 €
Cost of treatment	7,633.2 €
Cost of transport	3,440 €
Materials sent to landfill	56.65 t

Scenario 4 : Z_2, Z_3 and Z_1

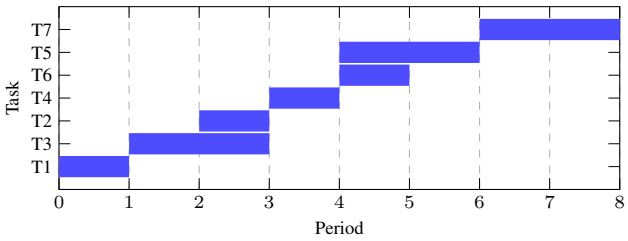

Fig. 4. Gantt Schedule of Scenario 4

TABLE VII

ECONOMIC AND ENVIRONMENTAL RESULTS OF SCENARIO 4

Indicator	Value
Profit of the project	385.3 €
Revenue	29,368.9 €
Cost of workers	16,960 €
Cost of resources	1,220 €
Cost of treatment	7,363.6 €
Cost of transport	3,440 €
Materials sent to landfill	54.16 t

Scenario 5 : Z_3, Z_1 and Z_2

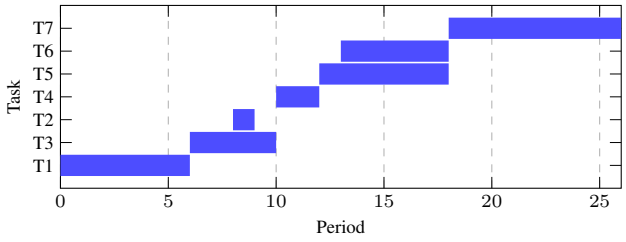

Fig. 5. Gantt Schedule of Scenario 5

TABLE VIII

ECONOMIC AND ENVIRONMENTAL RESULTS OF SCENARIO 5

Indicator	Value
Profit of the project	-19,092.3 €
Revenue	30,607.95 €
Cost of workers	32,000 €
Cost of resources	8,510 €
Cost of treatment	6,230 €
Cost of transport	2,960 €
Materials sent to landfill	29.85 t

Scenario 6 : Z_3, Z_2 and Z_1

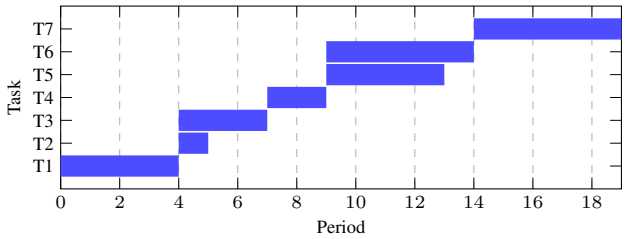

Fig. 6. Gantt Schedule of Scenario 6

TABLE IX

ECONOMIC AND ENVIRONMENTAL RESULTS OF SCENARIO 6

Indicator	Value
Profit of the project	-25,332.2 €
Revenue	30,607.95 €
Cost of workers	40,320 €
Cost of resources	6,430 €
Cost of treatment	6,230.2 €
Cost of transport	2,960 €
Materials sent to landfill	29.85 t

B. Discussion

We normalized the results of the objectives functions and inverted the direction of Z_2 and Z_3 to make the comparison easier and more consistent. This gives the trend plot shown in Figure 7.

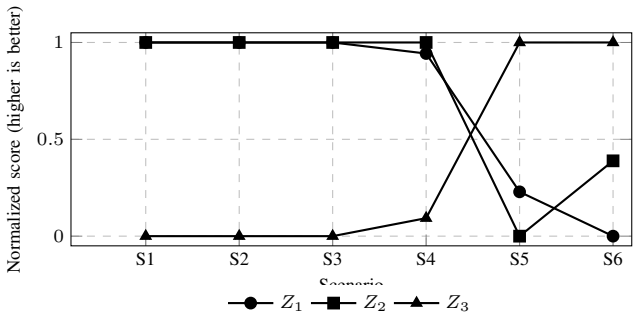

Fig. 7. Normalized objective functions across scenarios

First, the fictive instance was designed to test the MILP model and check the consistency of its outputs. Therefore, the observations below should be interpreted with caution: they are only preliminary, and the test and analyses should be extended to real case studies to better assess the relevance and practical value of the model.

The results of the six scenarios highlight clear trade-offs between economic performance, completion time, and circularity. Scenarios 1 to 3 lead to the same solution, which we will use as a reference as it reflects a more traditional practice. They achieve the highest profit (1939.5€) and the shortest makespan (8 periods), but at the expense of a very large landfilled quantity of materials (56.65 t), meaning that circularity is strongly sacrificed when Z_3 is not ranked first. Scenario 4 keeps the makespan at the minimum duration with 8 periods while slightly improving landfilling objective (4.4% less), but this comes with a sharp drop in profit (80.1%

lower), showing that even a small improvement in circularity can create noticeable economic impacts. In contrast, when circularity objective is prioritized (Scenarios 5 and 6), landfilling drops dramatically to 29.85 t, which is close to half of the quantities landfilled in the reference solution, but this improvement results in much longer schedules (325% and 237.5% more than the minimum duration) and much lesser profits (984.7% and 1306.1% more than the reference solution). Overall, these preliminary results confirm that the lexicographic order can drastically change the solution, and they suggest that, for this instance, better circularity is obtained mainly by accepting significant economic losses and longer schedule, while the best economic and time outcomes can be achieved simultaneously but lead to poor circularity.

Looking more closely at the objective values trends, the normalized plot shows a clear "flip" between Z_1 and Z_3. Scenarios 1 to 3 sit at the top for profit and makespan, but at the bottom for landfilling. Scenarios 5 and 6 show the opposite pattern: they reach the best landfill score, but profit collapses and the makespan becomes much worse. This indicates that, for this instance, the model cannot improve circularity objective without triggering major changes in the chosen recipes, and resource and workforce use, which then propagates to higher labor and equipment costs and longer schedules.

Finally, the fact that Scenarios 1, 2, and 3 return exactly the same plan suggests that, in this instance, optimizing profit and makespan are not in conflict once landfilling is not prioritized. This also means that if decision makers want to improve circularity, a purely lexicographic approach may be too rigid, because ranking landfilling objective the shift to landfill first immediately leads to solutions that are economically defavorable. A natural next step would be to explore intermediate compromises, for example by using an ϵ-constraint approach that sets an upper bound on landfilling objective and makespan and then maximizes profit, in order to identify solutions that improve circularity while keeping profits positive and schedules reasonable.

V. CONCLUSION

This paper proposes a optimization model for planning building deconstruction projects. The main contribution is a proposal of a MILP formulation that connects three decision layers in a single optimization framework. The model is intended to be used as a decision-support tool to explore the trade-offs between economic performance, project duration, and circularity outcomes.

We tested the formulation on a fictive instance to verify its consistency and feasibility. The results show that the model produces coherent plans and that the lexicographic approach can generate very different solutions depending on the chosen priority order. In particular, the experiments illustrate that prioritizing circularity can strongly reduce landfilling, but may also lead to much longer schedules and much lower profits, while the best economic and time outcomes can be achieved simultaneously but yield poor circularity.

A key limitation of the current model is that task durations and material quantities are assumed to be perfectly known and fixed prior to planning. In practice, these inputs may evolve due to many external factors, such as imperfect initial diagnosis, the discovery of asbestos or other hazardous materials requiring specific interventions, weather conditions, work accidents, or differences in worker skills, equipment and productivity. These factors can affect both the quantity of recoverable materials and the duration of tasks. A natural next step of this work is therefore to model these parameters as uncertain and to extend the solution approach to handle uncertainty in the deconstruction planning problem.

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