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Waste Management of Building Ceramic Materials Using the DfD Technique: Sustainable Development and Environmentally Friendly

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A B S T R A C T

Nowadays, in modern societies, growing activities in construction affairs and their economic development have been resulted construction wastes and so much demolition in the past three decades. Most of these wastes have not been treated and therefore caused severe damages to the environment. In this research, after reviewing construction and demolition management methods and their accessories, the selected method, which is proportional with Iran circumstances and can be used as a design technique for disassembly in waste management, is suggested according to the implemented interviews and questionnaires. In this proposed method, it has been attempted to cover all economic, environmental, technical and social aspects of waste management in Iran and eliminated defects in methods offered in other studies. The present methodology is somewhat a descriptive manner that shows the recommended idea using sketch-up software, interviews and questionnaires in order to confirm the execution capability of the project. Results showed that design for disassembly (DfD) technique in the field of ceramic floors, wall tiles and building facades is capable of decreasing environmental pollutions as a result of construction materials and can also increase economic advantages in construct and deconstruct stages until a sustainable construct compatible with the environment is achieved.

1. INTRODUCTION

Construction activities can improve public facilities and general mood of life in different ways. Nevertheless, the construction industry has been criticized as the main factor of environmental demolition. Wastes out of construction and demolition constitute about 25 to 30 percent of the total solid waste annually [1]. These wastes should be considered as a major issue because of their detrimental effects such as land depletion, energy consumption, solid waste production, dust and gas emissions, sound pollutions and natural resource consumption. Proper waste management that establishes one of the most important components of the sustainable development and has economical, environmental, technical, political and social aspects is a necessity for the achievement of sustainable construction. According to the EU Waste Framework Directive, recycling construction and demolition wastes should be reached 70% until the year 2020 [2]. Waste management Legislation carried out in 2004 in Iran. Moreover, it is considered as a great and role-playing step in the history of waste management. At the present time, due to the spread of urbanization culture and population growth living in cities, the urban community health provision constitutes one of the most important issues that requires special attention by urban managers and planners. The proper waste management needs a good knowledge about lots of processes including collection, recycling, disposal and constructional waste compounds. Materials recycling methods should be developed through preserving economical, environmental, technical, political and social interests simultaneously. The council of Europe estimates that 200 million tons of construction wastes are produced in Europe each year [3].

This number is about 14 and 136 million tons in Australia [4] and in America [5], respectively. According to statistics, 60 million tons of construction wastes are also produced in Iran each year, about 17 million tons of which belong to Tehran metropolis. Indeed, more than 3 billion dollars worth of construction waste is disposed of in Iran [6]. Regarding the fact that 30 to 40 percent of greenhouse gases are produced due to construction industry [7], proper waste management can take a big step towards achieving

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targets of sustainable development from the economic and environmental point of views.

Ever-increasing production of construction wastes without a proper management plan has damaging impacts including environmental demolition, extra costs for reproduction of materials and disposal of old materials, social negative effects on the society and human health and also negative effects on the political credibility. Thus, we can fundamentally decrease these destructive impacts via recognition of widely used construction materials and long-run planning for their effective recycling.

As a consumer and/or exporter of ceramics and tiles, Iran is ranked among the top ten based on the amounts of consumption (340 million square meters in 2016) and export (126 million square meters in 2016) [8]. Therefore, in order to improve the quality life, it can significantly alleviate construction wastes using modern technologies explained later.

In this research, a new design for disassembly (DfD) method and its application has been introduced for construction waste management in Iran. However, in the field of waste management, using this technique in Iran is unprecedented, it is rare in other countries and it has been introduced at a theoretical level. In the proposed method, structural and nonstructural elements are designed in a way, which can be easily disassembled without any demolition impacts. The main objective of current research is to present a proper waste management of the flooring system, wall and building facades with a sustainable development perspective and using DfD technique. The selected research method contains some aspects including: 1) literature regarding DfD method, 2) extraction of executive ideas for domains of flooring system and building facades, 3) , an executable three-dimensional modeling with the help of sketch-up software and 4) showing applicability of the project based on the confirmation of the competent engineers.Concerning the substantial amount of the design conception domain for disassembly in the construction and time constraint, after introducing the overall conceptions, the research domain is restricted to applying this conception into the industries of ceramic floor, wall tiles, building facades and its obtainable benefits. Correspondingly, research conditions are not prepared for the project field examination due to the economic and equipment reasons. Thus, for the executive project, we applied three-dimensional modeling and suggested it to the competent engineers of the Road, Housing and Urban Development Research Center in order to obtain approval for the project administrative capability.

2. RESEARCH LITERATURE

To explain waste management principles, at first, we introduce effective indices related to the construction and demolition waste production, which are following as [9-13]:

- ❖ Design changes (key factor)
- ❖ Waste management rules
- ❖ Site space dedicated to the waste management implementation
- ❖ Adoption of low waste construction technologies
- ❖ Waste management culture within an organization
- ❖ Investment in waste management

The design changes index, which is one of the most important factor in the construction and demolition waste production, is fully controlled and also devoid of waste in design technique for disassembly that is the overall situation for the low waste technologies.

In interviews conducted in Australia and China, low waste technologies have been recognized as the leading factor influencing on the construction waste relief [14, 15].

After introducing effective indices in the waste production, other operational indices in economical, environmental and social performances regarding the waste management design are turned out.

The main indices for measurement of economic performance (cost and benefit) about waste management [9] are as follows:

- ❖ Expenditures of collection, arrangement and disassembly of the wastes
  Reuse expenditure of the waste
  Recycling cost
- ❖ Waste transfer cost from the construction site to the disposal area
  Waste assortment cost in the disposal area
  The penalty paid for the waste unlawful pileup
  Benefits obtained from selling waste material
- ❖ Saving waste transfer cost from the construction site to the disposal area
  Saving disposing waste cost in the disposal area

Efficient indices in the environmental performance of waste management are following as [9]:

  Lands devoted to waste disposal
  Water pollution
  Sound emissions
- ❖ Environmental impacts of illegal accumulation of waste in public living environment

Effective indices in the social performance of waste management are as follows [9]:

- ❖ The knowledge of employees with waste management
- ❖ Provision of job opportunities
- ❖ Physical working conditions
- ❖ Long run impacts on health
- ❖ Worker safety during waste management implementation
- ❖ Public consensus on waste management
- ❖ Impacts of prohibited waste disposal on social image
- ❖ Public request for correction of prohibited waste disposal.

2.1. What is the design for disassembly (DfD)?

Two DfD is a new concept in construction association and design for environment (DfE). DfD entails construction of buildings that at the end of the life cycle of its elements or change of usage there would be no need for their total destruction. Design for disassembly is an intelligent strategy for preventing obsolescence and alleviation of economical and environmental factors in building demolition. According to the studies performed in America, about 60% of material flow (other than foods and fuel) in America's economy is consumed by the construction industry, which their management can play a significant role in economic growth and environmental conservation.

DfD utilizes for flexibility, transformation, decrease and increase of all buildings and it can be also applied to provisional, recreational and even military structures, other than commercial and residential buildings.

2.2. What conceptions related to DfD technique

With regard to the extreme environmental and economic requirements for the achievement of a sustainable construction that is compatible with the environment and is less tending to resource consumption, the need of DfE and DfD techniques in the construction industry is sensed [18]. The final objective of DfE and DfD is to lessen environmental damages using sustainable designs. It is worthy to note that the DfD is a subset of DfE [17,18]. In the environment design of the construction industry, it is attempting to design structures with the least waste and disposal that are not dangerous for the environment and are adaptable with nature known as green and sustainable.

2.3. Sustainable development

There is a process for acquiring sustainability in each sort of activity, which requires resources, prompt and integral substitution. Sustainable development together with economic growth and human development in a society or in an advanced economy tries to achieve continual development beyond economic progress [19].

Issues mentioned below relate to the design of current buildings [16]:

- Difficulty in recycling current materials due to their complicated chemical composition
- Expenditures of demolition workers, the process of recycling mixed materials and using mechanical, thermal, optical and acoustic equipment disassembly
- Using connection techniques such as wind nails and adhesive materials make the disassembly process so hard.
- Ownership change that necessitates recycling and demolition costs.

Table 1 shows a review of previous research about the utilizing waste ceramic materials.

3. RESEARCH METHOD

3.1. Implementation of DfD technique

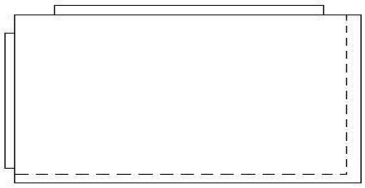
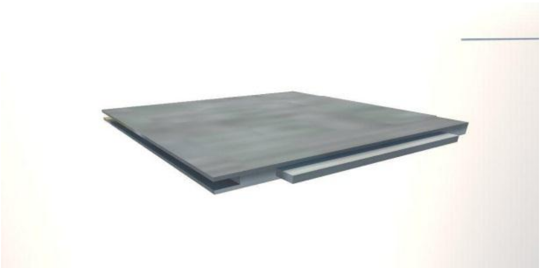
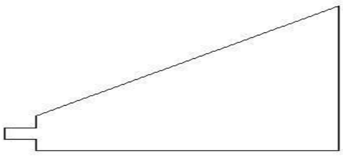
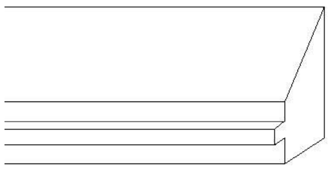
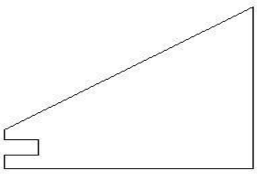
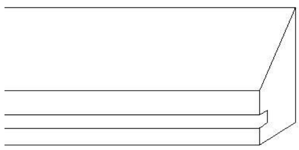
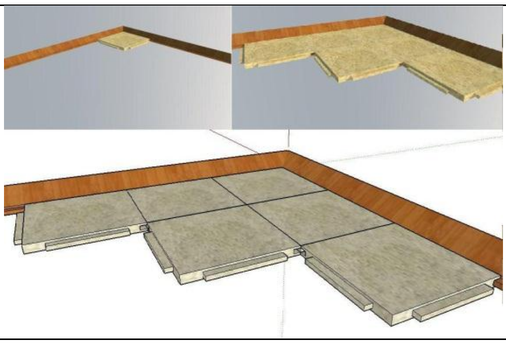
In this method, elements are interlocked as slide puzzles. Our suggested method that has been confirmed via consultation with the engineers of the Road, Housing and Urban Development Research Center to design buildings and its final approval, would be explained with all the specifics in the following sections. Its three-dimensional designing has been carried out by sketch-up software. This is one of the complicated and efficient software for three-dimensional works, especially in the field of architecture. It also applies to civil and mechanical engineering, and for designing a software model. According to the studies conducted in code 55 (general technical specification of construction works), no specific types of materials have been recommended and all dimensions of ceramics, tiles and stones are based on the average dimensions of the market [28]. Table 2 shows the implementation of DfD technique for floor ceramic, wall tiles and stone facade using the sketch-up simulation software.

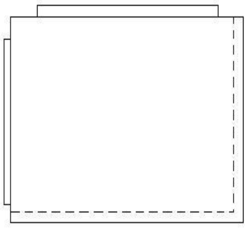
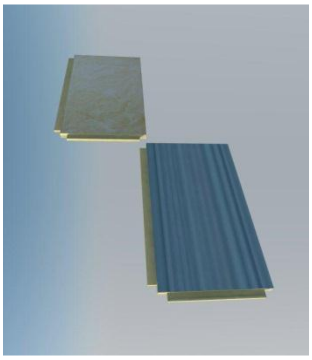
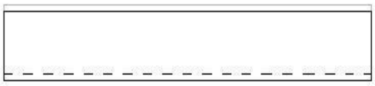
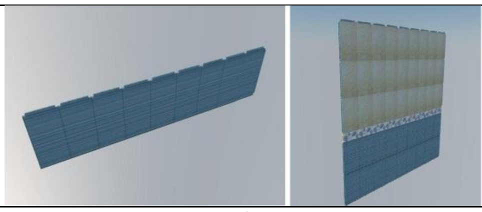
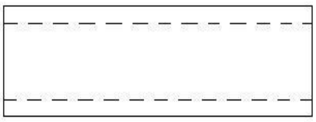
TABLE 1. Previous research on the waste ceramic materials

Title	Objectives, Methods, and Findings	Publish Year	Ref.
Properties of concrete produced with waste ceramic tile aggregate	The possibility of using waste ceramic tile in concrete had been studied in this experimental. For investigating, the characteristics of ceramic aggregate were measured and then being grind. They were used in concrete as the substitute for coarse aggregates with 0 to 40 percent of substitution and also for sand with 0 to 100 percent of substation. The results revealed that generally using waste ceramic tile lead to enhancing the properties of concrete.	2012	[20]
A review on the usage of ceramic wastes in concrete production	The ability of ceramic wastes to act as a pozzolanic material in the production of cement has been effectively explored. The results proved that the applied temperatures for manufacturing of these tiles (about 900 ºC) were sufficient to activate the pozzolanic properties of clay. Also, the cement blend performed better after optimization (11-14% substitution); and the morphology of the cement blended and ceramic waste were the same. Then, the cement blend mixed with other pozzolanic materials. Sanitary ware and electrical insulator porcelain wastes were some wastes which were investigated for usage as aggregates in concrete production. This review had been concluded with focus on investigating whether ceramic wall tile wastes used as partial substitute for cement and fine aggregates could prove to be beneficial since the two materials were the most high-priced during concrete production.	2014	[21]

Ceramic tile waste as a waste management solution for concrete	Floor tile waste aggregates (FTWA) in concrete applications can substantially reduce the negative environmental effects and exhaustion of the natural resources. In order to reuse and so to reduce the volume of the ceramic waste which occurred during the production of ceramic, it was possible to use as aggregates in the production of concrete. In this study, the mechanical and physical properties of the produced concrete from floor tile waste aggregates were investigated. C30/37 quality concrete was produced by using two different floor tile wastes. The properties of these concretes were compared to the produced reference concrete. These results showed that the produced concrete from floor tile waste had better physical and mechanical characteristics than conventional concrete, thus a new application area to selective recycling of ceramic floor tile waste and its use in the production of concrete.	2012	[22]
Characterization of ceramic waste aggregate concrete	The current study focused on the mechanical characterization of waste ceramic wall and floor tiles aggregate concrete. Ceramic wastes sourced from construction and demolition wastes were separated from other debris and crushed using a quarry metal hammer. Ceramic tiles were sieved into fine and coarse aggregates in line with standards. Other usage materials were gravel, river sand, cement and potable water. Workability of the fresh concrete was checked through slump test, and concrete cubes of 150 mm dimensions and cylinders of 100 mm×200 mm were cast in the laboratory. After 24 h of casting, the concrete samples were demolded and cured by immersion in water tank at temperature of 22 ^{o}C. The compressive and split-tensile strengths of the hardened concrete samples were determined after curing them for 3, 7, 14 and 28 days. Results showed that the compressive strength and split tensile strength were increased appreciably by the curing age that was more than the conventional concrete.	201	[23]
Utilizing of waste ceramic powders as filler material in self-consolidating concrete	The using of filler materials finer than 0.125 mm is quite effective on the fresh state properties, strength and durability of self-consolidating concretes. The most common filler materials for self-consolidating concretes are minerals, blended cements and natural or artificial pozzolans. In this study, the usability of granulated waste ceramic powder as the filler material in self-consolidating concretes was investigated. The properties of the self-consolidating concretes with 550 kg/m^3 dosage and cement was replaced with (WCP) in the amounts of 5%, 10%, 15% and 20% (by weight) were determined in the fresh and hardened phases. As a result, it was determined that the use of WCP had some positive effect on the viscosity of the mixes. However, a slight decrease was observed on the strength values based on the substitution of cement with ceramic powder. It can be concluded that finely ground WCPs could be evaluated up to 15% for production of self-consolidating concretes as a filler material if the strength and flowability parameters were evaluated together.	2017	[24]
Use of waste ceramic tiles for road pavement subgrade	The aim of this study was to evaluate the use of waste ceramic tiles as a raw material in the design of road pavement subgrade. Instead of disposal in landfills, ceramic tiles can be used in highway engineering applications, thereby reducing their potential impact on environment and may result in a substantial decrease in design thickness of a pavement. California Bearing Ratio (CBR), Unconfined Compressive Strength (UCS), compaction, odometer, and swelling tests were conducted on the mixtures prepared with waste ceramic tiles and low-plasticity clay (CL)-type soil. Waste ceramic tile contents in the mixtures were 0%, 5%, 10%, 15%, 20%, and 30% by dry weight of the specimens. The results revealed that the addition of waste ceramic tile increased the CBR value of soil, while addition of it reduced the UCS value of soil. Besides, an increase in dry unit weight (γ_{dry}) and a decrease in corresponding water content (w) by an increase in the amount of waste ceramic tile were observed in the compaction tests.	2017	[25]
Ceramic ware waste as coarse aggregate for structural concrete production	The aim of the study reported in the present article was to seek a sustainable means of managing waste from the ceramic industry through the incorporation of this type of waste in the total replacement of conventional aggregate (gravel) used in structural concrete. Having verified that the recycled ceramic aggregates met all the technical requirements imposed by current Spanish legislation, established in the Code on Structural Concrete (EHE-08), then it was prepared a control concrete mix and the recycled concrete mix using 100% recycled ceramic aggregate instead of coarse natural aggregate. The concretes obtained were subjected to the appropriate tests in order to conduct a comparison of their mechanical properties. The results showed that the concretes made using ceramic sanitary ware aggregate possessed the same mechanical properties as those made with conventional aggregate. It was therefore possible to conclude that the reuse of recycled ceramic aggregate to produce recycled concrete was a feasible alternative for the sustainable management of this waste.	2013	[26]
Enhancing the bioactivity of a calcium phosphate glass-ceramic with controlled heat treatment	In this paper synthesis and characterization of a bioactive calcium phosphate glass-ceramic was presented, synthesized using a facile method. The glass-ceramic samples were synthesized with heat treating of the parent glass at appropriate temperatures, where different calcium phosphate crystalline phases were grown in the parent glass samples during the heat treatment. The amounts of elements and oxides in the parent glass were determined by X-ray fluorescence analysis. Using differential scanning calorimetry method glass transition temperature of the parent glass, and the temperature range for heat treatments were determined. Several calcium phosphate crystalline phases were identified in the glass-ceramic samples. With the increase of the heat treatment temperature from 540 ^{o}C to 560 ^{o}C, β-$Ca_3(PO_4)_2$ and β-$Ca_2P_2O_7$ crystalline phases became the dominant crystalline phases among the other crystalline phases in the glass-ceramic samples. Bioactivity of the glass-ceramic samples was investigated by immersing the samples in Ringer's solution for 7, 21 and 28 days. By analyzing X-ray diffraction patterns, Fourier transform infrared spectra, and scanning electron microscopy images of the samples immersed in Ringer's solution, the formation of hydroxyapatite on the samples confirmed. The results showed that the samples with β-$Ca_3(PO_4)_2$ and β-$Ca_2P_2O_7$ crystalline phases were more bioactive than the others.	2017	[27]

TABLE 2. Simulation and implementation of DfD technique for floor ceramic, wall tiles and stone facade

Floor ceramic	Description
	Ceramic plan: Ceramic is designed as a puzzle with two male and female edges. In the software, we draw a square line tool measuring 60 by 60 cm.
	Three-dimensional ceramic: In the next step, the three-dimensional pitching of the desired tab will be done. Then, this step is done for other three volumes, and the volume is painted by the paint bucket tool. The thickness and the depth of the volume are 7 and 15 mm, respectively. (The required adherence is achieved by interlocking ceramic edges into female edges)
	Cutting heel band (male): Male heel band is placed in the female ceramic working perimeter and thus ceramics are firmly fixed and integrated with the wall.
	Three-dimensional view of the male heel band:
	Cutting heel band (female): Female heel band is placed in male ceramic working perimeter and thus ceramics are firmly fixed and integrated with the wall.
	Three-dimensional view of the female heel band:
	Three-dimensional view of the implemented floor ceramic: A plastic sealing band placed between the seams, during the ceramic arrangements

Wall tiles`	**Description**
	Tile plan: A rectangular is designed using a lines tool measuring 25×50 cm (Tile is designed as a puzzle with two female and two male edges)
	Three-dimensional view of the tile: The measuring tool is used to measure the desired dimension to triple the 3D volume. Each side of the right and left is 5 cm and the top and bottom are 0.3 cm. The thickness of the pinsetter is 4 mm. (The required adherence is achieved by interlocking male edges into the female edges)
	Pillar band plan: Pillar band has a pair of the male and female edges.
	Cutting pillar band: The pillar band is fixed to the wall and decreases the height weight of the tiles.
	Three-dimensional view of the implemented tiles along with the pillar band: During the tiles arrangement, one plastic sealing band is placed between their seams.
Stone facade	**Description**
	Plan of stone facade: A rectangular is designed using a lines tool measuring 30×70 cm (Stone facade is designed in puzzle form and only by two lower and upper female edges)
	Three-dimensional view of the stone facade: The measuring tool was used to measure the desired dimension to triple the 3D volume. The top and bottom are 0.5 cm. The thickness of the pinsetter is 1 cm. (The required adherence is achieved by interlocking the male edges of metal lattice into the female edges of the stone facade)

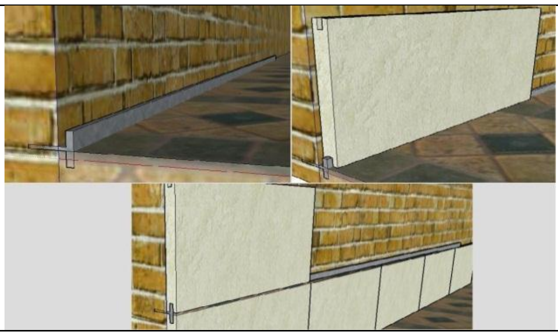
	Three-dimensional view of the metal lattice of T-shape: The dimensions of the wings of this metal grid are designed in accordance with the thickness and pitch of the stone; so that the thickness and length of the wing are 1 cm (It's a shield of T-shape, which is welded onto the sections that are to act as a facade)
	Three-dimensional view of the implemented stone facades in the metal lattice of T-shape: Stone facades are placed in row sequence between T-shape lattices that have been welded in the parallel form.

TABLE 3. Model verification [29]

	Successful factors					
	Implementation capability	Easy to implement	Easy to demolish	Economic benefit	Environmental benefit	Social benefit
No.1	√	√	√	√	√	√
No.2	√	√	√	√	√	-
No.3	√	-	√	√	√	√

3.2. Model verfication

This section presents successful factors of the model that are confirmed by Road, Housing and Urban Development Research Center (2016) [29]. Assessment and confirmation process is a repetitive procedure that is commenced by referring to a draft model to experts working in this research center. The research center that has more than 25 years of background in executive activities, after reviewing this model, they have identified successful and unsuccessful factors through the tickle (√) and minus (-) marks respectively, shown in Table 3. As can be seen in Table 3, most factors have been confirmed by research center with a majority of consensus.

4. ECONOMIC ANALYSIS

4.1. Impact of DfD technique on the economic aspect of the project

In the traditional method of ceramic, tile and facade-working project, due to using mortar and assuming that these operations are permanent, there are the initial several expenses including mortar working, employing labor for project demolition or its repair, collection, transportation and waste storages. However, these expenses are omitted in the DfD technique. In addition, economic benefits can be acquired by the sale of materials at low prices, which have been entirely and easily disassembled.

It is worthy to mention that the expenses of metal lattice implementation are added to facade operations in the DfD method.

4.2. Comparison of construction expenses on the traditional and DfD methods related to the life cycle of a building

Since the life cycle of a building in Iran is assumed 50 years, we have attempted to consider and compare expenses of initial construction, repairs and modification operations in these two methods during these5 decades. So, the extreme economic importance of DfD method can be quantitatively understood about the life cycle of the structure. This comparison is ultimately presented through the pertinent charts and tables.

Assumptions:

- ❖ Three times variation of ceramic floor and wall tiles during the life cycle of the structure, because of repairs and updating operations (approximately every 12 years.(
- ❖ Two times variation of stone facade during the structural life cycle, due to repairs, depreciation and updating operations (approximately every 17 years.(
- ❖ A 7% inflation rate .

Table 4 shows the implementation and demolition expenses in the traditional and DfD methods.

TABLE 4. Implementation and demolition expenses in the traditional and DfD methods

Expenses	Traditional implementation (Thousand Tomans= Million IRR)	DfD implementation (Thousand Tomans= Million IRR)	Traditional demolition in 2015 year (Thousand Tomans= Million IRR)	DfD demolition (Thousand Tomans= Million IRR)
Stone facade	Implementation + stone facade (50+31)	Implementation + stone facade (60+40)	4	4
Ceramic floor	Implementation + ceramic (30+29)	Implementation + ceramic (35+26)	3.6	0
Wall tile	Implementation + tile (30+29)	Implementation + tile (35+26)	3.6	0

4.3. Disassembly in DfD method

Regarding the fact that the stone facades, ceramic floors and wall tiles are entirely disassembled in the DfD modern method, therefore, it has great economic value. The minimum economic value with a 7% inflation rate for disassembled stone facades, ceramic floor and wall tile is considered one-third of their announced prices for the pertinent year.

- ❖ According to the demolition expenses in the DfD, it is taken into account to be equal to demolition costs in traditional method in order to provide for a reliability margin in the stone facade domain. Nevertheless, in the ceramic floor and wall tile domain, operations are considered costless due to ease of disassembly operations.
- ❖ In executive operations of the following years, expenses of metal lattice working (250000 IRR) are initiated from implementation costs.

Tables 5 and 6 and Fig. 1 and 2 are related to the implementation costs of two methods for the useful life cycle of building.

TABLE 5. Construction cost in the traditional method for the stone facade

	At first	17 years later	34 years later
Implementation cost (Thousand Tomans)	81	260	800
Demolition cost (Thousand Tomans)	0	13	40
Total cost (Thousand Tomans)	81	273	840

- ❖ Important conclusion: In structures that the stone facade has been implemented by the modern method rather the traditional one, 30% of the cost decrease will be observed for variations in the following years:

TABLE 6. Construction cost in the modern method (DfD) for the stone façade

	At first	17 years later	34 years later
Implementation cost (Thousand Tomans)	100	240	750
Demolition cost (Thousand Tomans)	0	13	40
Stone sale profit (Thousand Tomans)	0	63	200
Total cost (Thousand Tomans)	100	240+13-63=190	750+40-200=590

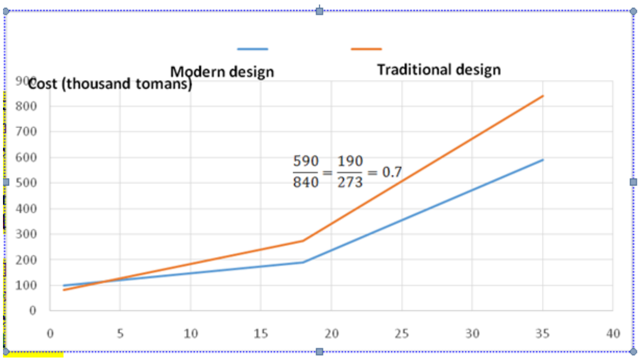


Figure 1. Construction cost in the traditional and DfD methods during the structural useful life cycle for the stone façade

TABLE 7. Construction cost in the traditional method for ceramic floor and wall tile

	At first	12 years later	24 years later	36 years later
Implementation cost (Thousand Tomans)	59	130	300	670
Demolition cost (Thousand Tomans)	0	8	18	40
Total cost (Thousand Tomans)	59	138	318	710

Table 7 shows the construction cost in the traditional method for ceramic floor and wall tile.
Table 8 shows the construction cost in the modern method for ceramic floor and wall tile.

TABLE 8. Construction cost in the modern method for ceramic floor and wall tile

	At first	12 years later	24 years later	36 years later
Implementation cost (Thousand Tomans)	61	140	300	700
Demolition cost (Thousand Tomans)	0	0	0	0
Sale profit (Thousand Tomans)	0	26	60	130
Total cost (Thousand Tomans)	61	140+0-26=114	300+0-60=240	700+0-130=570

- ❖ Important conclusion: In structures that ceramic floor and wall tiles have been implemented by use of modern method rather than traditional one, approximately 20% of cost decrease for changes will be observed in the following years:

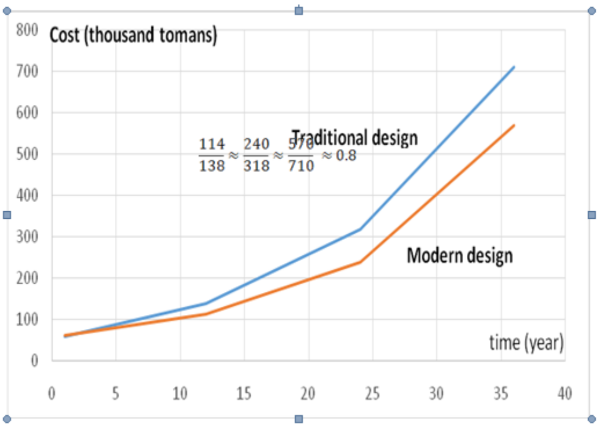


Figure 2. Construction cost in DfD methods during the structural useful life cycle for ceramic floor and wall tile

5. IMPACT OF DfD TECHNIQUE ON THE PROJECTS ENVIRONMENTAL ASPECTS

In the traditional method of ceramic, tile and façade working project, due to using mortar during implementation and demolition operations, there are some environmental pollutions while in the DfD method, the pollution issues have been resolved. Furthermore, pollutions based on the transportation and even cement production operations are prevented along with reduction of cement consumption. Above all, large volume production of construction wastes and their disposal in nature would be prevented via reusing ceramic, tile and stone facade materials [17]. With regard to the annual consumption of ceramics and tiles in Iran and the world (that are 400 million square meters and 12000 million square meters, respectively), wastes production can be significantly alleviated by proper management through executing DfD method. Moreover, substitution of at least 50% of ceramics and tiles can be helpful [8]. In this case, ceramic and tiles production would decrease by half that entails a significant reduction of environmental pollutions, including air, acoustic pollutions and primary resources reduction.
Utilizing the DfD technique in the field of ceramics, tile and stone facade paves is the way to achieve a sustainable and environmentally friendly construction objective through alleviation of pollutions, which is initiated from production and destruction processes during their short life cycle in the traditional design. Additionally, prolonging life cycle of the products and their productivity by designing a modern DfD are the other ways. Highly sustainable and green constructions can be implemented through growth and development of a modern DfD in all aspects of construction and applied materials.

5.1. Impact of the DfD technique on the projects technical, social and political aspects

In the traditional method of ceramic, tile and façade-working project, more time and skills are required for implementation and demolition operations from a technical point of view, but in the DfD method, these operations are more easily accomplished with a lower time.
In the traditional method, due to the hardship associated with the work and large emissions of acoustic and environmental pollutions, which are resulted from construction and demolition wastes, very unsatisfactory impacts on the society and social image of the activity are expected. Nevertheless, in the DfD method, as a result of simplicity and the rate of construction and demolition operations, trivial acoustic and environmental pollutions are produced, which create a significantly positive effect on the social image of the operations.
Progress in the designing structures using DfE and DfD techniques leads to the promotion of national political

image due to its leadership in this field, as for the waste management, it creates more effective rules.

6. CONCLUDING REMARKS

Nowadays, the need for the waste management is felt more than ever because of the expansion of development and construction activities in urban societies. Since the most effective technique for the waste management is considered as management and reduction of wastes, their objectives are realized in time of waste production for stone facade, ceramic floor and wall tiles. So, these wastes are minimized and old materials can be reused in other projects without any special recycling operations.

Positive impacts of the DfD technique on different aspects of the sustainable construction are as follows:

- reduction of construction and demolition expenses
- a significant reduction of construction wastes and their negative impacts on the environment
- a reduction of construction time and ease of technical implementation
- a reduction of negative social impacts including acoustic pollutions and social nuisances
- the establishment of more precise and productive implementation rules in the field of waste management

Based on the construction waste management and tendency to sustainable and environmentally friendly construction, we need a management method that possesses the most possible potentials for that construction. The DfD method plays a significant role in the reduction of construction wastes by simplifying construction and demolition operations. Furthermore, together with making opportunities for technical, economical, social and political savings, popularity and productivity of this management method have been more enhanced. Since the DfD and DfE techniques have highly extended domains, they have applied for both interior and exterior of buildings in the designing system. Moreover, other constructional domains can implement this technique and benefit more from its advantages in the construction such as in skeleton system, ceilings and walls.

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