Management of Residential Construction Waste: A Case Study

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Abstract- *With speedy urbanization the quantum of construction& demolition waste (C&D Waste) is continuously growing. Construction enterprise has a terrible effect at the environment. This study is to calculate the quantity of wastes generated through construction of a residential building in Jalgaon and following the ARRRD waste control approach to lessen waste on site. The maximum used waste minimization approach observed in ARRRD idea will be the reduction of waste. Some usual figures for the waste generation of few key materials are studied and the primary reasons of waste with inside the region are discussed. The results indicate that the waste generated of building materials in the construction industry is fairly high. Most of this waste may be averted via way of means of enforcing preventive measures, mostly related to managerial improvements. The study also points that by waste minimization, the overall cost of the project can be optimized.*

Keywords- Construction waste, waste minimization, ARRRD technique, permissible waste, cost optimization.

I. INTRODUCTION

The construction industry in India is booming. Already at 10 per cent of the GDP, it has been growing at an annual rate of 10 per cent over the last 10 years as against the world average of 5.5 per cent per annum. Almost 70 per cent of the building stock in India is yet to come up. The built-up area is expected to swell almost five times from 21 billion sq ft in 2005 to approximately 104 billion sq ft by 2030.The Indian construction industry is characterized by challenges such as low productivity, lack of skilled labor, time and cost overruns, etc. These are associated with considerable waste present in the construction sites. Globally, cities generate about 1.3 billion tonne of solid waste per year. This volume is expected to increase to 2.2 billion tonne by 2025, says a 2012 report by the World Bank.[15]

Nevertheless, practice of CWM and application of low-waste management technologies in the Indian Construction sector are still at a lower level compared to those of some advanced Countries, such as USA, UK and Australia Only few measures are been taken in India regarding CWM.

Increasing urban migration and a high density of population will make management a difficult issue to handle in the near future, if a new paradigm for approaching is not created. No preventive measures are taken during construction to minimize waste and majority of waste is been dumped to landfill. However, this leads to a negativity in the environment.

The commitment of project participants, including laborers, subcontractors, and general contractors, are more important in effective waste management systems than new technologies or regulatory guidelines. This result quantitatively supports the preceding research emphasizing that the factors related to human commitment have a relatively greater impact on the waste management performance.

IMPORTANCE OF C-WASTE MINIMIZATION

Waste minimization provides financial benefits in terms of reduced transportation cost, less disposal cost, minimized purchase quantity and price of raw materials, reduced purchase price of new materials when considering reuse and recycling, increased returns achieved by selling waste materials etc. Environmental benefits consist of minimized amounts of waste disposed off at landfills, which therefore extend the lifespan of landfills, reduced environmental effects as a result of disposal, e.g. noise, pollution, and decreasing global warming. Other benefits include increased site safety, enhanced work efficiency and productivity and improved image of the company [1]

1) Reuse of construction waste materials.
2) The components of construction waste include;
3) Cement concrete, Sand, Bricks, Steel, Cement plaster, steel, rubble, stone and Timber wood.

Reusing materials 1) Cuts costs related to the production and transportation of new materials 2) Reduces the demand for new resources. and 3) Eliminates the need to send

waste to landfill sites. Many common construction and renovation materials can be reused or recycled.
For example:

- **Concrete** – can be broken down and recycled as base course for building driveways and footpaths.
- **Bricks**-can be used in construction/ landfill, landscaping and also can be recycled into brick aggregates which can be used as pavement base material by proper mix proportions of fly ash and cement.
- **Stone**-can be reused for plinth formation, masonry construction, landscape purpose, ledges, platforms, window sills, coping etc depending upon the form of available stones.
- **Tiles**-Its difficult to extract tiles from walls in proper shape and size in order to find them suitable for reuse. Even broken pieces provide a good opportunity to artists for decorative pieces. Special effect in drive ways, pedestrian subways can be smartly created.
- **Construction debris**-It can be recycled to manufacture paver blocks for light traffic areas and masonry blocks. Other uses of processed debris include use in lean construction for levelling purpose, as mortar for masonry and landfilling.
- **Untreated timber** – is used as firewood or mulched. Large pieces can be re-milled and put back to use in construction
- **Asphalt paving** – is crushed and recycled back into new asphalt for paved roads

Saving construction waste is not considered as an important parameter in the cost equation. The economic and environmental benefits to be gained from waste minimization and recycling are enormous (Guthrie at al. 1999). It benefits the construction firms in terms of cost reduction and increased profit. Implementing CWM will reduce production costs increasing contractor's competitiveness and a better public image.

Due to least priority given to appropriate site waste minimization and management systems in Indian construction industry leads to generation of huge quantities of material waste every year. This problem is not only detrimental at environmental level as most of the waste is disposed off in landfills but also in economic terms as waste materials have their specific economic values before getting mishandled. Waste is classified in 3R (Reduce, Reuse, Recycle) principle due to this we can minimize cost of project. This study emphasizes the need to plan and develop waste management strategies for construction projects.[1]

1.2 SCOPE OF PROJECT:

The scope of study is limited to Jalgaoncity. Total quantity of construction waste generated is calculated. It is then compared to the permissible waste according to IS 1200.Even the extra cost due to wastage of material on site is calculated showing cost optimization form the case study.
Total plot area is 2500sq.ft. type of building is residential which is located at area.

1.3 OBJECTIVES OF REPORT:

1. Tostudy the concept of Construction waste management.
2. Determine the quantity of construction waste produced during construction of a residential building.
3. Comparison with the permissible waste according to IS 1200.
4. To reduce the overall cost of construction i.e Cost optimization by calculating the amount of waste generated and suggesting measures for waste management.
5. Results and Discussion on construction waste are determined along with the outcomes of the report.

1.4 **METHODOLOGY**:

1. To study the construction waste management for a building from various research paper, international journals and latest scenario of construction waste management.
2. To collect the present rates of different construction materials such as cement, sand, steel, aggregates and bricks. And also to find out the quantity of these materials used in the case study.
3. Amount of waste generated is calculated for G+3 storey building.
4. The overall cost of project is calculated and cost increased due to material waste is calculated and finally the cost optimization can be done.
5. Interpretation of the information based on above case study and drafting suitable results and recommendations on waste minimization, reuse and recycling of waste.

Solution such as reuse of construction wastes will be taken into consideration for waste minimization which consequently results in reduction of final cost of the construction project.

II. LITERATURE REVIEW

In this literature review the relevant literature on CWM and Reduction in overall cost related to construction projects, the concept of ARRRD and finding out strategies for waste minimization. The reviews of other authors helped me to understand the topic easily.

Priyadarshi H. Sawant et.al (2012) author explains waste in construction is important not only from the perspective of productivity but also from the environmental considerations. Many times actual percentage of waste generation is much higher than envisaged initially causing needless utilization of resources. It means there is a plenty of scope for enhancing project productivity simply by taking waste out of construction. Disposing of waste is not the right solution. Many countries are facing the problem of scarcity of dumping yards and exhaust of landfill spaces forcing researchers to look for an alternate and efficient waste management system. The literature review is carried out to identify construction waste management techniques being used in the construction industry. An attempt is made in this paper to quantify concrete waste and locate causes of its generation in housing projects. Research study observations are derived from the data analysis of five building projects located in different cities of Maharashtra state in India. The average level of concrete waste is 4.7 % of the estimated quantity that is more than double the permissible standard of 2 %. Three approaches of waste minimization - waste as project management function, ARRRD and value chain are discussed giving the guideline to design waste management plan
In another study, the cost of waste identified found varying in between 5 to 15% of the total construction cost in the studies carried out by Ramaswamy (2004) in India.

R.ShreenaShankari et .al,(2017) highlighted the importance of waste management in construction, amount of waste generated in construction project, methods of minimizing waste and best methods involved in construction industries for International Journal of Advance Engineering and Research Development (IJAERD) Volume 5, Issue 03, March-2018, e-ISSN: 2348 - 4470, print-ISSN: 2348-6406 @IJAERD-2018, All rights Reserved 437 minimize waste. Identified the factors that can contribute to materials that are minimum wasted. which is a need to concentrate even on materials that are least wasted as any small improvement in reduction of waste generated adds to the advantage in improving the overall efficiency of the project and enhance the construction industries performance with cost saving benefits. And suggested waste management plan which only minimizes the material waste but also improves the profitability and decreases the cost overrun

Prasiddh v. Nanera1, Jayraj V. Solanki, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056, Volume: 07 Issue: 05 | May 2020.The study states that wastage of material in construction industries are usually because of documents, site management, procurement stage, material handling, and operational attributes. Mostly waste generates in case of design changes in structural plans and architect plans. Materials consists 50-60 % of total cost of the project. This analysis should be used in each and every construction project. It is very important as it gives the information about the waste occurring in construction projects and how to overcome it. Mainly this analysis work focuses on the cost optimization. The total cost of the project optimizes if we follow the above-mentioned procedures and techniques to reduce the waste. This analysis will help to procure the right amount of material without being wasted.

Abhishek Singh et.al (2020) states different causes of construction waste and are identified and classified. Through quantitative survey, data for ranking the identified causes of construction waste is obtained and then analyzed with the help of Microsoft excel 2010 software application. Using rank formula within Microsoft excel 2010, different ranks are calculated and assigned to the identified causes of construction waste. The top five ranked nine causes of construction waste are identified and discussed along with their remedial measures. It is highly advisable to all the designers, contractors and construction managers to follow the mentioned remedial measures in order to avoid the generation of construction waste.

Gazi Tamiz Uddin et.al, (2021) author presents a general summary of current construction waste management practices in Sylhet city. For this reason, a field survey was conducted to monitor the current status of construction waste management systems like waste generation, on-site handling and storage. Within the field survey, the chosen sites area unit ascertained and data regarding generated wastes are collected. Different types of waste are found. The quantities and qualities of the waste are identified. It is found that for most of the waste there is a moderate relationship between the site area and the number of generated wastes. Then 4R principles which are: Recycling, Reuse, Reduction and Recover is conducted for the management of these wastes. Hereafter, the government initiative and mass awareness are necessary to stimulate the use of recycled components in construction industries and lower the quantity of waste engaged towards landfill. Using thoughtful planning system, design of buildings and landscapes can play role in operating construction development activities without causing any despair of environment.

Chunxiang Hua et.al, (2022) the author illustrates the relationship between many factors and sets several incentive policies using system dynamics. It could provide a deeper understanding of using incentive policy to promote C&D waste recycling. Furthermore, accurate incentive policies are calculated and so are the effect of incentive policies on C&D waste recycling. Hence, it would provide the decision foundation for the government.

ShitawTafesse et.al(2022), author aims to analyze the significant socioeconomic and environmental impacts of construction waste and to indicate management strategies. An extensive review of the literature and interviews with construction expertswere used to identify waste impact factors. Then a questionnaire survey was conducted based on a five-point. The result showed that construction waste becomes a challenge for almost 95.71% of ongoing construction projects. However, only 57.14% of the construction companies have recorded and measured the volume of material waste. From purchased materials, 6–10% is recorded as waste that led to project cost overrun. In addition, there is no professional assigned to handle waste issues in 75.71% of construction companies. The study also indicates that project cost overrun, pollution of the environment, reduction in profit and failure of construction firms, excessive consumption of raw materials, and public health and safety risks are ranked as the five major impacts of construction waste, respectively. Employing a waste management officer, using prefabricated or off-site components, implementing strong onsite management practices, reusing and recycling materials leftover on the sites, and practicing green building codes and specifications are measures devised to mitigate construction waste and its impacts.

Centre for Science and Environment (CSE) article on Construction and demolition waste, New Delhi,2014, states that he construction industry in India is booming. Already at 10 per cent of the GDP, it has been growing at an annual rate of 10 per cent over the last 10 years as against the world average of 5.5 per cent per annum. Almost 70 per cent of the building stock in India is yet to come up. The built-up area is expected to swell almost five times from 21 billion sq ft in 2005 to approximately 104 billion sq ft by 2030.

III. ARRRD APPROACH

Waste minimization tools avoid / eliminate the generation of waste at the source or reduce the waste by recycling and reusing for identified purpose. If waste can't be avoided at the source it can be minimized by different ways such as optimizing / reducing the use of resources and reusing existing materials etc. Recycling can further reduce its impact. The residue only can be disposed of at the end. This waste management hierarchy is termed as ARRRD approach. This approach to manage construction waste in a sustainable way is encapsulated in the following hierarchy shown in fig.1. To implement this approach effectively, identification of cause of waste and its measurement is essential.

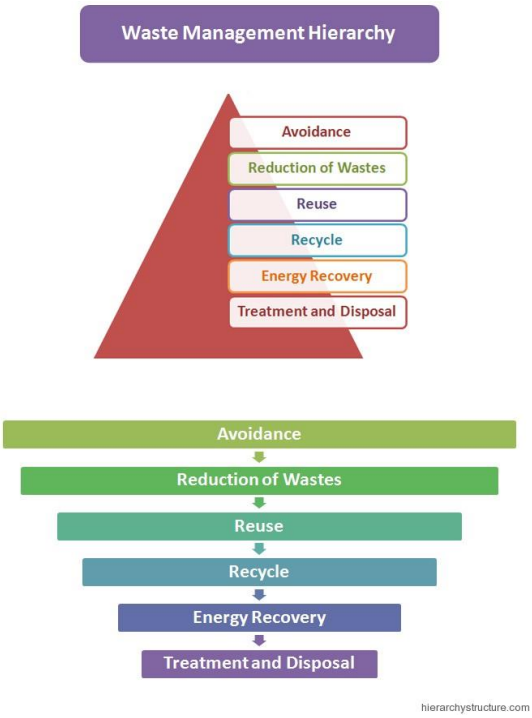


Fig 1: Waste Management Hierarchy.

Waste minimization strategies include zero waste, integrated recycling, international approaches, reuse of materials, resource optimisation, waste reduction, and deconstruction. Examination of the waste management hierarchy and life cycle management of material is used to improve the understanding of reuse and recycle opportunities.[1]

IV. DATA COLLECTION

A residential construction project of G+3 is studied in Jalgaon, Maharashtra.

Table 1 -Basic Information on Case study.

NAME OF PROJECT	
TYPE OF PROJECT	Residential
Location	Jalgaon
Basic information	G+3
Project Architect	Mr. Niraj Mantri
Structural Consultants	Mr. Bhavsar
Plot Area	2500 sq ft.
Built-up Area	1561 sq ft.

Table 2- Material and price list

Materials	Price list
Bricks	14rs/pc
Cement	350rs/bag
Sand	3000rs/brass
Steel	70/kg
Coarse aggregate	2500rs/brass

As per IS 1200: Part 18: 1974 Method of measurement of building and civil engineering works: Part 18 construction and demolition, the above table shows certain standards for waste percentages to be applied in making estimations for the bill of quantities.

Table 3: Construction material wastage allowances (IS 1200)

Type of material	Wastage allowance (%)
Cement	4-5
Sand	4-5
Aggregate	2-3
Brick	5
Steel	3-4
Floor tiles	5
Wall tiles	5
Wood	5-8
Paint	4-5

The survey suggests that the Jalgaon construction industry is able to handing over many new housing initiatives in coming year. The construction enterprise the quality of About 75% of the work contracts are labor intensive and 25% are labor plus material type of work contract. There is more awareness, sense of liability for the labors being working on site. So the material, equipment are used consciously. These are normally time bound contracts. All this directly or indirectly leads to generation of material, time and money waste for any project. Contractors need to be educated regarding construction waste management, so that awareness is spread among the labors and even the client should consider this as an important issue.

V. DATA ANALYSIS

After data collection by case study and site visit, the analysis is done. All information was collected from architect plan, price list of materials and Sr. engineer and the analysis for all the activities during construction was done such as actual quantity of cement, sand, steel, aggregates and bricks were found out.It is than compared with the estimated quantity and analysis is shown by graphs below. Even the cost was taken into consideration of these materials as an aim for cost optimization. The difference in the cost was calculated and amount of waste generation is found out. The cost analysis is shown by Tables and graphs below.

Table 4:Estimated quantity of materials required.

Sr. No.	Building Materials	Unit	Rate/uni	Estimate qty	Total Amt
1	Cement	Bags	350	1873.2	655620
2	Sand	Brass	3000	84.27	252810
3	Aggregate	Brass	2500	63.22	158050
4	6" Bricks	Nos	14	37464	524496
5	Steel	kg	70	16053	1123710
	TOTAL ESTIMATED COST OF MATERIALS				2714686

In Table 5, the actual quantities of the 5 materials were calculated activities wise such as PPC Footing, Footing, Ground floor PCC, Columns, Staircase, Lift room, RCC Ground beam and slab with beams.

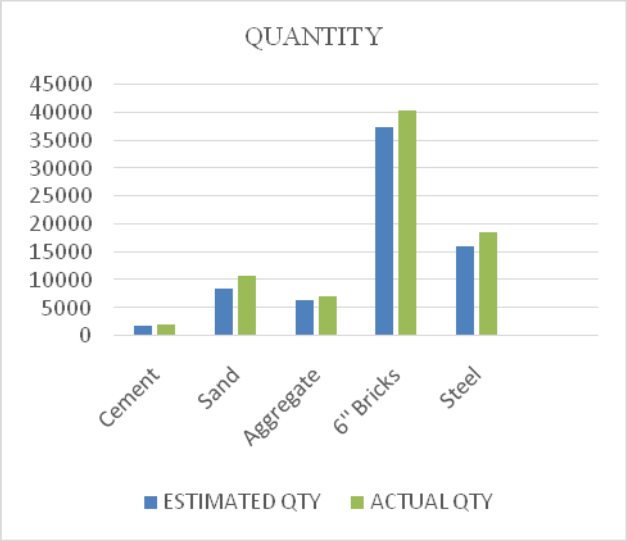
Table 5: Actual quantity of materials required.

Sr. No.	Building Materials	Unit	Rate/ Unit	Actual qty	Total Amt.
1	Cement	Bags	350	2027	709450
2	Sand	Brass	3000	107.5	3,32,500
3	Aggregate	Brass	2500	71	177500
4	6" Bricks	Nos	14	40500	5,67,000
5	Steel	kg	70	18573	13,00,110
	TOTAL ACTUAL COST OF MATERIAL				3086560

QUANTITY ANALYSIS.

Table 6: Comparison of Estimated and Actual quantity used on site.

MATERIAL	ESTIMATED QTY	ACTUAL QTY
Cement	1873.2	2027
Sand	8427	10750
Aggregate	6322	7100
6" Bricks	37464	40500
Steel	16053	18573



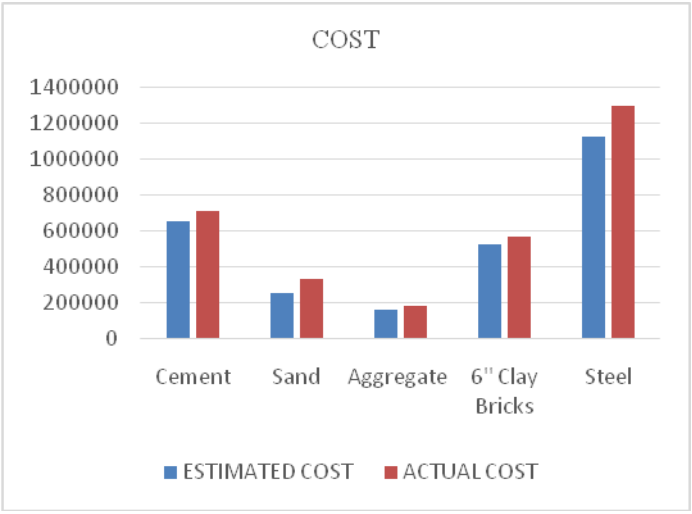
Graph 1: Quantity comparison of building materials

Difference in the quantities of materials can be noted from above table and graphs.

COST ANALYSIS.

Table 7: Comparison of Estimated cost and Actual cost

MATERIALS	ESTIMATED COST	ACTUAL COST
Cement	655620	709450
Sand	252810	3,32,500
Aggregate	158050	177500
6" Clay Bricks	524496	5,67,000
Steel	1123710	13,00,110
TOTAL	2714686	3086560



Graph 2: Cost comparison of building materials.

The total estimated cost of materials for residential building is 27,14,686 and the actual cost turns out to be 30,86,560.

In fact if the cost varies by more than 5%, then re-estimation is recommended. Hence the actual variation is not at all in the acceptable range. The case study directly indicates that there is a tremendous scope for application of waste minimization techniques and to save material. This will lead to the economic benefits as well as environmental benefits too.

VI. CONCLUSIONS &DISCUSSIONS

From the study it is concluded that wastage of material in construction industries are usually because of documents, site management, procurement stage, material handling, and operational attributes. Mostly waste generates in case of design changes in structural plans and architect plans. Materials consists 50-60 % of total cost of the project. This analysis should be used in each and every construction project. It is very important as it gives the information about the waste occurring in construction projects and how to overcome it. Mainly this analysis work focuses on the cost optimization. The total cost of the project optimizes if we follow the above-mentioned procedures and techniques to reduce the waste. This analysis will help to procure the right amount of material without being wasted. The following suggestions can be given for the waste control and consequent economy in the project:

1) Broken bricks can be used for water proofing.
2) Coarse sand can be used for flooring.
3) Broken tiles can be used in ramps in front of main doors.
4) Pieces of steel can be used as cut bars (cross reinforcement)
5) Marble pieces can be used in clear cover of slabs.
6) Recycled aggregates can be used in filling preferably.
7) The material inventory should be maintained precisely.
8) The material procurement should be rationalized.
9) The material storage guidelines must be followed.

REFERENCES

[1] Priyadarshi H. Sawant et.al, Sameersinh V. Alone," construction waste: source identification, quantification and its management in housing projects", conference/ICSBE2012/SBE-12-94,2012.
[2] Job Thomas and Wilson P. M,"Construction waste management on India",American Journal of Engineering Research, e-ISSN: 2320-0847 p-ISSN: 2320-0936, Volume-2, pp-06-09,2013

[3] Shah, Zenith "Analysis of Construction and Demolition Waste for Infrastructure Projects", Conference paper, PT101914, April 2015.
[4] R.Shreena Shankari, D.Ambika, S.S.Kavithra," A Perception on Waste Material Minimization in Construction Industry", International Journal of Scientific Development and Research, ISSN: 2455-2631 , Volume 2, Issue 3,March2017.
[5] Aishwarya Zunjarrao, "Construction Waste Management", International Journal of Engineering Research & Technology, ISSN: 2278-0181, IJERTV7IS040137, Vol. 7 Issue 04, April-2018.
[6] Abdul Latif Hamid, Amit D. Raval, Dr.Jayeshkumar R. Pitroda, "A Review Paper on Construction and Demolition Waste Management", International Journal of Engineering Research,ISSN:2319-6890 Volume No.8, Issue Special 4, pp : 36-39 ,Feb. 2019.
[7] PrasiddhV. Nanera and Jayraj V. Solanki," Cost optimization through construction waste Management", International Research Journal of Engineering and Technology, e-ISSN: 2395-0056, Volume: 07 Issue: 05 | May 2020.
[8] Yuchen She, NilupaUdawatta and OlubukolaTokede," Research trends in construction and demolition waste management in Australia",International Conference of the Architectural Science Association 2020, pp. 2020 and 915–924.
[9] Abhishek Singh,Tahsinur Rahman Warsi," Causes of Construction Waste in the Building Projects within India – An Analytical Study", International Research Journal of Engineering and Technology, e-ISSN: 2395-0056 Volume: 07 Issue: 08 | Aug 2020.
[10] Gazi Tamiz Uddin et.al, Md. Babul Mia, TahmidSadman and Md. Altaf Hossain," An Assessment on Waste Management Practices in the Construction Sites of Sylhet City", Journal of Materials Science Research and Reviews 8(4): 150-163, Article no.JMSRR.74865,2021.
[11] Swarna Swetha K, Tezeswi T.P, Siva Kumar M.V.N," Implementing construction waste management in India: An extended theory of planned behaviour approach, Environmental Technology &Innovation,ELSEVIER, 27,102401,2022.
[12] Jeonghyun Kim(2021),"Constructionand demolitionwaste managementin Korea: recycled aggregate and its application", Clean Technologies and Environmental Policy,10.1007/s10098-021-02177,2021
[13] Chunxiang Hua,Chenyu Liu,Jianguo Chen, Chenxi Yang, Linyan Chen, "Promoting construction and demolition waste recycling by using incentive policies in China ",Environmental Science and Pollution Research, 2022
[14] ShitawTafesse,YidnekachewEsayasGirmaand EliyasDessalegn." Analysis of the socio-economic and environmental impacts of construction waste and management practices", Heliyon8,e09169,March 2022.
[15] Centre for Science and Environment (CSE) article on Construction and demolition waste, New Delhi,2014 .