4.0 DATA ANALYSIS AND DISCUSSION

4.1 Introduction

Collected data from questionnaire and interviews can be summarized in several ways.

1. Private, government or semi-government organization wise
2. Project value wise (100Mn, 500Mn, 1000Mn, 2000Mn etc)
3. Grade of contractor wise (C1, C2, C3.....)
4. Type building wise (commercial, residential, public etc)
5. Project duration wise (6 months, 1 year, 2 years etc)
6. Construction stage wise (sub-structure, super structure, finishing)

Only large projects are accounted for data collections because large quantity of waste to be expected from these projects. But no any government contractors and few semi-government contractors are involved in large construction projects. Most of them are done by private contractors specially grade C1. Hence this analysis based on *private, government and semi-government wise is not suitable.*

Construction procedures and raw materials used are almost same in all projects although they have different values. So the analysis based on *project value wise and building type wise are not suitable.*

Analysis based on *contractor grade wise also not suitable* because all large projects are done by grade C1 contractors. *Project duration wise analysis is also not suitable* because most of large scale projects are in 2 years project duration or more.

My analysis based on **construction stage** wise because different types of waste are generated in each stage of construction. Collected data were divided into 3 stages of construction namely sub-structure, super-structure and finishing and major waste materials are identified separately. Main 5 causes for waste described in the report of Gavilan and Bernold (1994) and weather condition were assumed as main causes for waste in Sri Lankan context in the discussion.

4.2 Identification of major C&D waste items

Type and the quantity of waste generated from projects are based on the results of question No. 12 of questionnaire. Major waste items found in each stage of construction as percentage (by volume) given in the table (4.1) which was adopted from the summary sheet in appendix B1, B2, B3.

Table 4.1- Major waste items (Summary of data collected, Annexure B1, B2, B3)

Type of waste	Sub Structure Stage	Super Structure Stage	Finish Stage
	%	%	%
Concrete	4	16	11
Bricks	0	10	14
Blocks	0	13	11
Cement mortar	3	14	12
Rubble	3	4	2
Soil	80	4	4
Sand	3	10	7
Lime	0	0	0
Timber	4	11	8
Steel	2	3	2
Aluminium	0	2	2
Asbestos	0	0	2
Glass	0	2	2
Ceramic tiles	0	4	4
Plastic	0	3	2
Fiber materials	0	0	3
Wall paneling	0	0	4
Cardboard/ paper	0	4	11
Paints	0	0	1
	100	**100**	**100**

Above figures are evaluated from the data collected during single visit on site, not from waste auditing and hence it is not fair to generalize the figures to all projects. But for comparison purpose, these figures could be used.

Excavated earth (soil) can be assumed as major waste item in sub-structure level because excavation has to be done and material has to be removed from the site to accommodate the foundation. Most of the time, this soil is mixed with water and it cannot be used as filling material directly. The quantity of the excavated material can be estimated prior to excavation which is given in the Bill of Quantities (BOQ). But this quantities are always exceeded due to many reasons

such as over excavation for proper access, falling of sides, design changes etc. Excavated earth is in very high percentage in sub-structure level while very low percentages in other two stages. Low percentages in other two stages are due to minor excavations in elsewhere to construct simple foundations, clearing the ground for other purposes etc.

Low percentages of concrete, rubble, sand, timber, reinforcement can be seen as waste in sub-structure level with compared to the volume of soil. But quantity wise it is high. Due to site complexity in sub-structure level, those materials are mixed with soil and sent to the dump yard. As a structural purpose concrete piles are cast extra height and upper most part is demolished later to facilitate the pile cap.

Rubble can be seen as waste in other two stages of construction. These are the residuals from foundation construction.

Double digit figures are available for concrete, bricks, blocks, cement mortar, sand, timber etc as waste in super-structure level and finishing stage because these items are widely used in these stages. Concrete waste in super-structure is higher than other two stages and these come from

- Waste generated when casting of structural elements such as columns, beams, slabs, stairs, walls etc although use concrete pressure pump or hand deliver
- Damages to formwork while casting
- Demolition due to poor quality
- Excess ordering or mixing etc.
- Residuals from construction activities such as wall construction, plastering etc.
- Unusable timber formwork

No waste of bricks or blocks found in sub-structure level because these materials are not used for foundation construction.

Cardboard and paper materials are available in high percentage in finishing stage because they are brought to the site as packing material of other construction items such as tile, sanitary wares, glass, fixtures etc.

Timber waste is higher in super-structure level because formwork is the main item in concreting of structural elements. Some timber waste can find in finishing stage in considerable quantity. Timber planks from formwork, roof and ceiling timber off - cuts are the majority of them.

Other waste items such as glass, fiber material, paint, aluminium, wall panel materials, ceramic, plastic items etc could find in finishing stage as they are the raw materials use in this

stage of construction. Some of them are found in equal capacity in super-structure level because some finishing work started as parallel activities before completion of total structure.

Landscape materials and land clearing materials are also found in some projects. It is not included in table 4.1 because it is not common item for all projects but discussed in latter part of this chapter.

4.3 Causes for C&D waste in Sri Lankan projects

As given in chapter 2, Gavilan M. and Bernold E.(1994) documented in their report 5 major causes for waste such as due to

- Design errors and design changes
- Procurement errors
- Improper handling of materials
- Operation errors
- Residuals

In addition to that bad weather condition also to be considered in Sri Lankan context as a main cause for waste. Above factors have various influencing tendency for C&D waste generation according to the construction stage of the project. Answers for question No.10 of questionnaire provide necessary data to identify the weight of influence of each cause in each stage of the construction.

The table 4.3.1 shows the influence of each cause for waste at sub-structure level out of total 4 project visit which data adopted from the summary sheet in annexure B1.

Table 4.3.1 – Individual influencing factors for waste in sub-structure level

Causes for waste	Influence for site waste
Due to design changes	Low
Due to procurement errors	Low
Due to handling of materials	Low
Operation errors	Low
Residuals	Low
Weather conditions	High

Bad weather condition is the most significant reason for waste in this stage of construction which has to be addressed to minimize the waste generation.

In annexure B2 is given the summary of 11 site visit data in super-structure level. By giving arbitrary weight values for low influence = 0.25, medium influence = 0.5, high influence = 0.75, and assuming all site waste are due to this given causes, influencing factors for each cause can be summarized as given in table 4.3.2.

Similarly individual influencing factors for finishing stage is given in tables 4.3.3.

Table 4.3.2 – Individual influencing factors for waste in super-structure level

Causes for waste	Influence for site waste
Due to design changes	20%
Due to procurement errors	23%
Improper handling	17%
Operation errors	11%
Residual	16%
Weather conditions	13%
	100%

Procurement errors and design changes are most significant causes for waste in super-structure level which has to be addressed to minimize the waste generation.

Table 4.3.3 –Individual influencing factors for waste in finishing stage

Causes for waste	Influence for site waste
Due to design changes	30%
Due to procurement errors	14%
Improper handling	18%
Operation errors	12%
Residual	14%
Weather conditions	11%
	100%

Design change is the most effective cause for waste in finishing stage which has to be addressed to minimize the waste generation.

1. **Design errors and design changes –**

Design and detailing errors could happen due to following reasons

- Mistakes in architectural design
- Mistakes in structural design
- Design is not compatible with client requirements
- Discrepancies in architectural and structural drawings
- Last moment changes by client
- Non-qualified personnel engaged in design field
- Lack of experience of designers
- Single party keeping control power either Architect or Engineer, without compromising to achieve common goal
- Insufficient time duration for design
- Printing mistakes

Design of a structure is also a project and it needs a sufficient period of time to complete. Some clients do not consider about it and force to do it within a shorter period of time. But due to lack of resources with the designer, they might complete with lot of discrepancies. Sometimes design is perfect but may be contain printing errors in final issues.

C&D waste relating to design changes is very minimal in sub – structure level. Proposed foundations have to be changed due to some site obstructions which are very difficult to change such as public water lines, sewer lines, under ground electrical lines, encroached foundations from other buildings etc. Then extra excavation is possible and material collected as waste. Most of the time the design of foundation is dependant on the figures in soil report. If soil report is incorrect, foundation design has to be changed while construction in progress. As earlier described, in pile foundation structures, piles are concreted purposely little higher than required due to structural aspect. But some times piles are to be demolished more than planned to facilitate the pile caps if unforeseen service lines are found. Then concrete waste is possible but in low percentage. Even in rubble foundations no much waste is accountable due to design changes.

In super structure level, waste due to design changes is in medium level. Some structural elements such as columns, beams, slabs, walls are demolished as per request of client or consultant. Design and detailing errors are the mistakes in engineering design. These mistakes are some times not identified before do the structure. But after completion, some failures could be noticed and affected elements have to be demolished. Some examples are,

- Insufficient reinforcement in concrete beams, slabs,
- Incorrect finish levels given by designers
- Incorrect element sizes in concrete or steel structures
- Insufficient clear height to beam bottom or slab bottom

C&D waste generation is high in finishing stage of a project due to design errors and changes. Some finishes are not satisfactory with the client requirements and have to be changed accordingly. In that case structural components such as concrete columns, beams, slabs, walls etc might be demolished. Especially tiles, plastering, ceiling, pvc accessories etc can be seen in most of the sites as waste due to design changes. Comparatively these wastes are lesser in projects done by higher grade contractors due to experience and qualified construction personnel engaged in projects because the contractor use to communicate with client or consultant regarding any discrepancy before commencement of work.

There are some occasions either client or consultant or both use to change the design after construction due to many reasons. Before commencement of construction, some clients do not have clear picture about finished product although designers show them in the drawings but as the construction progress they realized that the finished product is not what they expected. Then the structure or finishes have to be altered to satisfy client's requirement and thereby C&D waste is generated.

Consultant or designer might change the design after construction when they do not have clear picture about final product. This is mainly due to the lack of experience. Paper qualification is not the mere criteria to choose a consultant or designer. They also should have sufficient construction experience in working with contractors prior to become consultants. Junior designers and structural consultants should get proper advice and guidance from seniors to avoid mal-practicing in the field. On the other hand, it is the client responsibility to select qualified team as consultants. When practicing as a consultant, he should possess a good knowledge about latest technologies available in the market relevant to his field to find best practice.

2. Procurement errors –

Mistakes due to three material conditions; over-shipment, under-shipment and mis-shipment can be considered as procurement errors. Some of them are,

- Excess ordering of materials
- Poor storage
- Poor quality materials
- Non-standard materials
- Under ordering
- Late ordering

Excess ordering of materials and poor storage of materials always creates waste. Poor storage is more common in Colombo projects due to congested environment. As a procedure, all material samples have to be submitted to consultant for approval with necessary documents such as test reports, manufacturer specifications etc. But due to some reasons poor quality or non-standard materials are reached to the site. Bricks, blocks, aggregates, steel, timber etc. are more common items in poor quality. Some of them are returnable but some are not and collected as waste at site. Under ordering and late ordering are directly affected in time and man power waste but indirectly affects the material waste. Some of procurement errors are usually caused by miscommunication either within the builder's organization or between builder and the vendor.

Foundation concreting is the major construction item in sub-structure level. Concrete waste is common problem due to miscommunication in ordering between supplier and site personnel. Probability of waste generation is higher in lower grade contractors due to less experience and less qualified staff engaged in procurement process.

C&D waste due to procurement errors are medium in super-structure level because number of items to be ordered are limited and orders are placed for required quantities .Main items such as cement, sand, metal, bricks, blocks, steel, formwork items are ordered as percentage of total requirement due to lack of space for storage. If not bottom most layers are kept on non- moving for long period of time and get wasted. Bricks and blocks which are low quality leads to waste.

C&D Waste due to procurement errors are medium in finishing stage of the project. Ordered Materials are not keeping within requirement or not match with the sample provided and some times those are not returnable. In some occasions finishing materials are ordered through sub-contractors or upon their request which included high wastage factor and the balance will be

wasted. Breakable items such as tiles, glass etc are ordered extra in keeping for tolerance and waste anticipated. Some times tiles are ordered extra in same batch of production to avoid mismatching with other inputs.

3. **Improper handling of materials** – Improper handling occurs when materials are
   - transporting to the site and within the site
   - storing
   - handling at work place etc.

There are lesser facilities in compacted sites in Colombo area to store raw materials such as sand, aggregate etc. which leads to waste. Materials may be damaged during fabrication, packaging, loading or delivery, unnecessary re-handling or improper storage without appropriate protection. There are some international standards and safety specifications for storing materials to avoid damages to materials and people such as maximum stacking height, minimum spacing etc. But most of site personnel are not aware of such standards and causes damage to the materials.

C&D waste generation is low in sub-structure stage due to small variety of materials being used at this stage. But most common materials such as concrete, sand, cement, aggregate, formwork materials etc get wasted due to the complexity of site in the foundation stage and working spaces are limited.

In super-structure level waste generation is not fairly high due to poor handling of materials. Most of materials affected are sand, cement, mortar, concrete, bricks, blocks etc which are most common materials use in this stage. People use to throw concrete and sand pans hand to hand to reach to its destination as speed delivery method. Bricks are thrown from one floor level to other level. This practice is more common in lower grade contractors while higher grade contractors are used to provide transport lift to each level.

Poor material handling procedures generate more waste in finishing stage of a project due to sub-contracting, more unskilled people being engaged and poor transporting method etc. Most affected materials are sand, cement, mortar, bricks, blocks etc.

4. **Operation errors** – Mistakes and errors in all construction activities at site can be included in this category. Lack of experience of construction personnel including workers, lack of proper tools and equipments are the main reasons for operation errors.

C&D waste generation is low in sub-structure level due to operation errors. Concrete pumping is common practice in most of the projects at this level which control waste but machine mixing at site increases the waste. Form work materials, rubble, sand, cement etc are collected as waste due to various operations in complicated site conditions.

In super-structure level operation errors are low in high rise building projects as the work is repeating for next floors but low rise building consists of different architectural views, waste may high. Poor workmanship is caused by unskilled labour, inadequate tools and equipment and poor working conditions.

Waste generation could be considered as medium in finishing stage of a project due to operation errors. But in lower grade contractors this may be higher than higher grade contractors due to lack of experience of staff and workers. Finishing works are included in brick or block walls, plastering, painting, tiling, rendering, fixtures etc. and most of them are given as sub contracting task without material. Sub contractors concentrate only on their daily output not of materials used. When less experience and un-skill workers are engaged in finishing works, low quality out put is to be expected and has to be demolished and thus waste generated.

Operation errors are comparatively higher in projects handle by government contractors than private contractors because private contractors are more concerned about their profit at the end of the project and take necessary precautions to minimize waste.

5. **Residual** – Residual can be defined in variety of ways depending on the material type. Basically it can be assumed as balance materials at work place which cannot use directly for any other construction activity and materials ordered to use for project activities which already cost to the project but remain as excess. Some examples are;

- Sand and aggregate delivered to the site and unloaded onto ground and most of the time bottom most layer is mixed with soil which cannot use for construction activities. This can be considered as residual waste.
- Always cement mortar is dropped to the ground in construction of walls, plastering etc which are not collected by workers and remain as residual
- Excess mortar and concrete take place at mixing place. Workers are used to mix cement mortar in the morning of the day without considering task it has to perform and after few

hours mortar could not be used due to time lag. They are wasted as residual at the end of the day.

- Reinforcement off-cuts, steel off-cuts, timber off-cuts, plumbing items, electrical items, ceramic tiles, roofing tiles and sheets, glass, ceiling materials etc are remain as residuals.

In sub-structure level, material residuals are very low as the types of material use are limited. But in finishing stage, various types of materials are used and transported to relevant locations and residuals can be seen elsewhere. Most of the operations are labour sub-contracting and sub-contractors are not interested to collect residuals. Most of finishing materials are left at site as off-cuts. Although usable materials are returned to the store, they remain at stores as residuals.

6. **Poor weather conditions** – Heavy rain fall will severely affect the construction progress in sub-structure level while generating more waste especially in raw materials. Excavated earth in foundations mix with water and has to be disposed as they are not suitable for backfilling. Material stock piles maintain in open area such as sand, metal etc are wasted due to rain. Bag form of cement also get wasted due to high humidity. Timber form work get warp due to high temperature when they are open to daylight and cannot be reused although insisted.

Effect of bad weather is very minimal in finishing stage of the project and lesser waste generation can be seen in this form because most of raw materials are under shelter.

The above described main causes for C&D waste generation are applicable to all kind of construction projects. But there are some other important factors affecting the quantities of C&D waste in projects such as grade of contractor (C1, C2, C3.....), status of contractor (Government, Semi-government, Private), project duration, qualifications and experience of construction personnel etc

All contractors in Sri Lanka are to be registered in ICTAD according to their capacities and expertise fields. Higher grade contractors posses well experienced and qualified work force than lower grade contractors. Thus higher quantity of C&D waste generation could be expected from lower grade contractors while lower quantity from higher grade contractors. Higher grade contractors are providing more facilities to their staff members to keep experienced crew with them and people can expect more job security. Most of low grade contractors recruit staff and

workers for their projects on hire and fire basis as they do not have sufficient jobs to continue same staff and workers. Then workers do not care of company reputation or prosperity and thus they do not have interest to minimize any kind of waste on site as they feel they do not benefit by doing so.

Government sector contractors are very few in Sri Lanka and they do not involve in major building construction too. Hence no any justification can be done about waste generation. But when comparing semi-government and private sector, waste quantities are comparatively high in semi-government contractors. Private contractors are always looking for high profits at the end of project. Private contractors are used to reduce their initial margin to win the tender under prevailing high competition in the construction industry,. If they do not control total waste generation, they might lose. Hence they try to minimize wastage as much as possible. But in the case of semi-government contractors, attitude towards minimization of waste is low. They have other interests. They focus on main targets and profitability of the organization such as limited working hours, over time payments, holidays, cash flow problems, lengthy procedures, promotions, management disputes, union problems, lack of technologies, lack of tools and equipments, less attitudes for changes etc.

There is a contradiction with the statement given by Poon, Ann, and Jaillon(2003) in Hong Kong in their research done for construction waste(Table 2.1). It reveals that low wastage consists in government sector while high wastage in private sector. But it differs in Sri Lankan context due to above said reasons.

High quantity of C&D waste could be expected from projects having short project duration than high duration projects. Contractors have sufficient time to arrange their stock piles or stores to keep raw materials with lesser wastage conditions in projects with higher duration. But in shorter duration projects, contractor always pay more attention to complete the project on time to escape from delay penalties. There are more possibilities for mistakes when is expedite and in correction of the mistakes it generate waste. Thus comparatively wastage is higher in short duration projects.

4.4 View of site personnel

Question Nos. 7, 8, 9 and 11 of questionnaire are designed to get the opinion of site personnel towards C&D waste management. It is visible in data summary that some personnel have an interest of waste management and some don't. Only few provided separate bins for waste collection at site. No one is permitted CMC to collect waste and all of them have no their own places to dump waste. Most of them have nominated subcontractors for waste collection and only few used to dump waste directly to low lands by them.

As usual most of the construction personnel pay less attention towards the management of C&D waste because they always concentrate on project progress. Although some are interested on this matter, they feel that it is not more important as project progress. Some project managers do not like to disclose the way of they dispose their waste because they do it always in illegal manner. A few project managers used to practice some waste management methods such as 5S but some consultants object to use recycle materials due to lack of knowledge about C&D waste management. Some of them complained that some consultants are strictly adhere to the specifications and standards and some are not having proper site experience to be flexible on site issues such as waste management. Most of the projects, all C&D waste are collected to one or two places in site premises without separate them. Thus it is very clear that construction personnel do not have any idea about C&D waste management.

4.5 View of waste collecting contractors

Building demolish contractors and waste collecting contractors are the key players in the field who are responsible for C&D waste generation, low land filling and illegal dumping in elsewhere.

Most of the demolishing contractors are collecting site waste on contract basis but all waste collecting contractors are not doing demolition. Building demolishing contracts are awarded to demolish old buildings or part of it and to dispose waste. Contractors are very keen to collect valuable items such as roofing materials, frames, electrical fittings etc without damaging them and resale them. Balance materials which cannot be sold are collected as demolish waste. Meantime

they are taking contracts from some other clients for low land filling and earn from both sides. Most of clients are not much interested about waste disposal method.

Waste collectors are taking contracts from the sites to remove construction waste on load basis. Whenever site personnel inform, they collect all waste. At the same time they are getting contracts for land filling and they also used to earn from both sides. Site personnel are also not interested about waste disposal method.

Both waste collecting contractors and demolishing contractors are not dumping construction waste beside roads because they do not gain anything by doing so. Illegal dumping on road sides are mainly done by individual building contractors and landlords who use their own vehicles for waste disposal because they do not have much contacts with people who need to fill low lands.

4.6 View of relevant authorities

As per the interview made with Colombo Municipal Council Engineers and other responsible officers in Local Authorities in Sri Lanka, it was revealed that there is no proper method followed by them to dispose C&D waste. Building owners are used to throw their demolished waste to the road edge and some of them are dumped to bare or vacant lands mainly government own lands. C&D waste on road sides are collected by municipal crew and used as garbage cover material instead of soil which is expensive. This collected waste consists of various materials which are not degradable such as concrete, asbestos, polythene etc. Some of waste items such as steel, metal, timber etc which has resale value are collected by some gangs and they make money. But non degradable items which are not having resale value are left in the land. In terms of sustainability this waste management method is not environmental friendly. According to the CMC Engineers, average quantity of C&D waste collected by CMC is less than 5% of total waste and hence it is not a problem for them.

C&D waste on other local authority areas other than CMC are used as bare land or low land filling material. These filled lands are later sold for high prices which could be used for construction of high rise or commercial buildings.

Rules and regulations related to the waste management in the country are imposed by the Environmental Authority of Sri Lanka. But currently no rules and regulations related to the C&D

waste management solely are enforced by the government and they are not even in proposed stage as it has no direct impact to the environment and normal life. But Environmental Authority insists to have some rules and regulations to control illegal dumping and low land fills and hence some guide lines are needed to improve existing rules and regulations towards C&D waste management.

4.7 Best Practice for Sri Lankan projects - Implementation of 3R

Major waste items on sites, causes for waste and their influence at various stages of the project, view of site personnel, disposal contractors and relevant authorities are discussed in above sub-chapters. In the literature review of chapter 2 discussed existing C&D waste management methods in Sri Lanka and other countries. With the help of above details, it is possible to develop a good practice for C&D waste management for Sri Lankan construction projects. Implementation of 3R (Reduce, Reuse, Recycle) will be considered as the best practice and discussed below. Waste minimization is the most important method in waste management to be discussed deeply in Sri Lankan context because this is a precautionary action to prevent waste generation. Other two methods (Reuse and Recycle) are relevant to the actions after waste generation.

4.7.1. Reduce of construction waste

Bruce McDonald and Mark Smithers (1996) revealed in their research report that there are two areas to be considered in C&D waste management. First is to minimize waste that is generated during the design and procurement phase of building contract and second is the development of on-site techniques for waste minimization. According to this statement and causes for waste discussed in chapter 4.3, the reduction of waste can be done in many ways of a project.

1. Waste reduction in design stage by eliminating design and detailing errors
2. Waste reduction in planning and procurement stage
3. Waste reduction in construction stage by introducing waste minimization techniques in site operations
4. Waste reduction in all occasions due to poor weather conditions

Design and detailing errors in both architectural and structural drawings, discrepancies of drawings and printing mistakes are more common in projects as described in the earlier sub chapter. To avoid this kind of errors, final drawings must be checked by experience senior

Architects and Structural Engineers before issue for construction. Main contractor also has a responsibility to check the discrepancies of drawings at the initial stage of the project. Most of higher grade contractors are used to practice this by allocating engineering staff.

. In the standard practice of construction it is a main responsibility of the designer to issue proper construction drawings to the contractor before the commencement of construction a compromise with client or developer in keeping with their requirements. Then detail drawings should be prepared by the contractor and submitted to the consultant for approval before commencement of any construction. If there is any discrepancy in preliminary drawings issued by the consultant, the contractor could correct them and there is an opportunity for contractor to give his proposal on best practice of construction of each and every element in every stage. This standard practice is called as preparation of "shop drawings" and it has been developed in mega projects to minimize the possible errors from both parties assuming that everybody's goal is to achieve the best finished product. In small projects or small contractors should provide at least "method statement" for every event or task.

Some design and detailing errors are due to lack of experience of designers. The Institute of Engineers Sri Lanka (IESL) and Institute of Architect Sri Lanka (IASL) as main government authorized bodies should take the responsibility and initiative measures to introduce qualified and experienced designers to the market. Some waste are generated due to design changes done at last moment by client, design is not compatible with client requirements etc. To mitigate this kind of waste, the designer should convince the client about his final product by real modeling or computer modeling. There are some computer packages available for computer modeling which can be done in minimal cost. Routing site visits by the client or full time his representative available at site will reduce this kind of conflicts.

If materials are ordered based on wrong information in design, materials are wasted. So procurement managers have an equal responsibility to reduce waste generated in procurement stage. There are some good practices on procurement in construction sites to reduce waste and some of them are given below.

- Reinforcement is the most expensive material and this could be wasted due to procurement errors. 6m long standard sizes are available in normal market but 12m long bars could be ordered from the supplier when orders are made for bulk quantities which minimize wastage due to unnecessary cut-offs.

- Timber off- cuts in formwork of foundation is common because required sizes are not available all the time in the market. This can be mitigated by ordering different sizes rather than in single size.
- If rubble foundation used for sub-structure, wastage in rubble is visible due to many reasons. Normal rubble stones used for foundations are specified as 6" x 9" but smaller sizes also needed for better bonding performance. Experience contractor knows the composition of rubble foundation and what quantities in each size to be. Some orders are placed for total quantity at once and supplier will complete the order. Then there is no chance to change the order for different sizes and automatically generate the waste.
- Sand is available mainly in 2 qualities. Sand consists of fairly large particles are suitable for structural works such as concreting, brick work, block work etc but it is not suitable for finishing works. It can be used after sieving but large quantities get wasted. Smooth sand which consists of fairly smaller particles is very much suitable for finishing works but not suitable for structural works due to structural aspects. So sand waste can minimize when orders are placed for suitable material.

Bricks and blocks are the main items are wasted at sites due to poor quality and wrong ordering procedures. Quality check has to be done before ordering the materials and also after delivering, to check the quality to ascertain whether it is same as ordered. Orders are to be placed according to the usage at site but not total quantity required for the project. This avoid damages happen to bottom most layers of bricks or blocks. "First come- First out" basic principle is to be inculcated among the store keepers to avoid waste.

In some occasions, structural elements such as concrete or steel beams, columns, slabs, foundations, stairs etc have to be demolished due to design errors or operation errors. But there are some new technologies available to improve the strength of structural elements without breaking and demolishing totally.

Reduction of waste at site operations can be discussed in category of waste, source of waste and methodology of reduction. Followings are the main items of waste generated commonly in Sri Lankan projects.

- Landscape, land clearing debris (green wood materials) and soil
- Concrete

- Sand and aggregate
- Masonry scraps, brick, blocks and rubble
- Metals (ferrous and nonferrous)
- Timber (dimensional lumber, sheet goods, planks, pallets)
- Plastics (films, containers, PVC products, polyethylene products)
- Glass
- Ceiling tiles /ceramic tiles
- Asphalt / bituminous, asbestos roofing and ceiling materials
- Insulation materials, Fibrous acoustic materials, Carpet and carpet pad
- Aluminium door and window assemblies
- Plumbing fixtures and equipment
- Mechanical equipment
- Lighting fixtures and electrical components
- Cardboard packing and packaging
- Others

Out of these waste items, more common and high volume items are only been discussed below.

Landscape, land clearing debris and soil

Land clearing debris is generated at the initial stages of a project while landscaping materials are at the completion stage. Site clearing has to be done at the initial stage of a building project to create sufficient space for construction and various type of trees, gravel, rocks, excavated earth, etc are generated as waste items. Some expertise Architects use to design buildings while protecting existing valuable trees in the premises as to get an aesthetical view to the final product. This can be assumed as a method of waste reduction. "Tree Free" area can be selected for building. But congested areas like Colombo which having high land value, most of Architects try to use existing land to the maximum with disregarding of existing tress etc. Most of buildings are designed as high rise due to limited resources and deep foundations are

accommodated to support the structure. Hence excavated earth, rock, gravel etc generation is inevitable. But all these items could be disposed in environmental friendly manner.

Landscape items are used at the completion of the project to enhance aesthetical view of the building and excess materials can be assumed as waste and most of items are degradable. Normally in most of projects, landscaping job is subcontracting to the expertise subcontractor. This is a good decision taken by the main contractor to reduce waste generation in many ways. Subcontractors do not like to lose their profit and hence they avoid excess ordering of materials. As they have well experience and trained people for the job and they know how to complete the job with minimal waste. But most of subcontractors are used to leave the residuals at site premises to clear by the main contractor which may be few truck loads. To avoid this kind of waste leaving at site, a clause must be included in the contract agreement to collect all residuals and clear the site by them and otherwise a penalty to be imposed.

Wasting of soil can be minimized if excavation done in a proper manner. Top soil is to be excavated to acceptable depth and send for composting or land fillings. Second layer can be excavated to a certain depth and send to a temporary dump yard which can reuse for foundation filling. Third or final layer which always mixed with water can use for land filling or reuse as foundation filling material by stacking for certain period of time.

Concrete

Concrete is the worst waste item generated in sites which are not degradable and it will be a threat to green concept of the environment. This has to be critically analyzed to take necessary precautions to reduce waste. Concrete is a mixer of sand, cement and aggregate to various mix proportions with water to get required strength. Before the initial setting of mixed concrete poured to a pre-arranged form work and allow to hard. After certain days of curing it is used as structural concrete element for the building. Site mixed concrete and ready mixed concrete are most common in sites. There are many ways of concrete waste such as

1. Residual of site mixed concrete
2. Residual of ready mixed concrete and excess concrete
3. Wastage in concrete placing due to weak form work
4. Wastage in concrete pumping, poor handling, transporting

5. Demolition of concrete structural elements due to incorrect location, shape, sizes, quality etc
6. Demolition of concrete structural elements due to design changes
7. Demolition of concrete structures due to over age
8. Demolition of concrete due to accidental damages and natural disasters

Site mixed concrete may be hand mix or machine mix. Irrespective of the method of mixing, concrete can be excess due to incorrect measurement and information. Normally this excess concrete is thrown away or hidden by the workers to avoid from getting any blame from their supervisors due to waste. If they inform their supervisors about excess concrete due to any reason, sometimes they could find a solution for excess. If the site personnel are acknowledged about concrete waste and reduction of waste, they could arrange an effective method to use excess concrete.

There is some wastage when using ready mixed concrete due to many reasons. Ready mixed concrete could be ordered to nearest 0.5 cubic meters and hence there is minimum excess of 0.5 m3 concrete always. There are some residuals in every concrete truck which is washed away at site premises or just out side. Although exact concrete volume calculated from the fabricated form work, excess concrete is inevitable. Concrete pressure pump is a common mechanism in placing of concrete in higher elevations which gives sometimes unexpected wastage. At the end of pumping operation there are some residuals in the pump bucket which is almost equal to 0.5 m3. In fact, ready mix concrete pumping is generating more waste, when comparing to the volume of casting, it is negligible. Excess concrete could be transformed to some other usable product such as concrete blocks, cover slabs, road paving blocks, lintels, lean concrete etc. All site people should be acknowledged about possible excess concrete in day to day operations and instructions to be given for early preparation works such as form work, people for work etc. to make use of them. Excess concrete can be used 100% when the pre-cast products become smaller. When using ready mixed concrete, raw materials such as sand, aggregate and cement waste at site is zero.

When large structures casting with ready mix concrete using pressure pump is high wastage may occur if ordering is not done in proper manner. In normal practice, initial order is placed to the batching plant according to the estimated concrete volume and last few orders are kept standby for final confirmation. This is more practicable in short traveling distances but not acceptable in

large traveling distances due to mechanical problems encountered in pressure pump. In that case last few orders are to be kept under supervision but precautions has to be taken to use excess concrete if excess or some raw materials are to be standby at site to mix concrete if less.

There are some occasions that concrete can be wasted when placing due to weak form work, leakage and breakage. This type of interruption could be avoided by proper inspection before casting commence. Especially higher grade contractors and organizations are appointed experience supervisors and technical officers to check the quality of form work before casting thus avoided this kind of waste. But lower grade contractors do not pay much attention to this matter and this type of waste is more common. Hence to reduce concrete waste due to poor form work, preplanned quality check process are to be implemented in all kind of casting even in small construction organizations and projects. The assistance of project consultant can be obtained easily to implement quality check programs on site.

Pre-cast concrete elements can be introduced to the projects such as columns, beams, slabs, stair cases etc to avoid in-situ casting at site thus avoid generation of concrete waste at site. This method has been implemented by some construction organizations in developed countries while some of Sri Lankan companies have adopted the same in some mega projects in Sri Lanka.

Demolished concrete is a common waste in most of the projects in various construction stages. One main reason for the demolition is operation errors such as wrong position, wrong dimensions, wrong shapes, wrong quality etc. Hence due to lack of proper supervision leads to incorrect work practices in work sites and wrong concrete structures are to be demolished later. Thus the concrete waste due to demolition is comparatively high in small projects and low grade contractors due to lack of qualified supervisory staff. There is a good practice of recruiting specialized field expertise for form work, steel, concrete etc in mega projects to minimize mistakes in each area. Although this is a good practice in construction, same thing cannot be applied to small projects or small contractors in 100% but to some extent it has to be practiced. "All rounder" concept is much suitable for such situations. All Rounder has an experience of doing most of the things to some extent (not 100%) but still can manage the situations.

Demolition of old concrete structures due to end of its life time is more common in developed countries to avoid any damage that could happen due to accidental breakage of structures. Designs can be done to accommodate for more life time such as 50 years or 100 years to reduce wastage due to more frequent overage.

Demolition of concrete structures due to accidental damages and natural disasters is a new source of waste which has to be considered in this era. Bomb blasting and road accidents are considered as accidental damages while Tsunami, floods, earthquakes etc are considered as natural disasters. This kind of wastage is inevitable and precautionary actions are limited. Buildings can be designed to withstand for natural disasters and most of qualified designers have already accommodated new standards for natural disasters.

Sand and aggregate

Sand and aggregate waste is mainly due to poor storage, poor handling and bad weather conditions (rain). Recently sand has become an expensive raw material in construction industry due to scarcity. Hence more attention is needed to reduce wastage. Normally sand piles are stocked in open area without providing any protection from rain. Some are mixed with soil on the ground. This problem is applicable to aggregate too. To avoid this kind of waste

- Separate places for each item to be allocated (smooth sand, coarse sand, each size of aggregate etc)
- Ground should be rendered or plate to be provided to avoid mixing with soil
- Steel plates or timber planks to be provided to cover the stock pile to a certain height (2m or 3m depending on the size of stock pile). This will avoid material mixing with others and any overflow. Although there is an initial cost involved, it is a long term investment.
- Avoid excess ordering (JIT concept in logistic)
- Avoid double handling as much as possible. Try to minimize transition points from stock pile to the last point of use.
- Use polyurethane or gunny bags to transport sand / aggregate to upper floors to reduce wastage.

Masonry scrap, bricks, blocks and rubble

This category includes clay bricks, cement blocks, rubble, plaster materials, lime etc which contributes more to the C&D waste. Some of reasons for waste are

- Demolition of old buildings
- Demolition of part of building for renovation

- Design changes by consultant or client
- Demolition due to incorrect construction
- Due to accidental damages
- Subcontracting of tasks
- Unskilled labour
- Poor storage facility, excess ordering and bad weather conditions

Demolition of old buildings and partly demolition for renovation purpose is more common case to be discussed in waste generation context. Most of demolishing contractors are interested on valuable and reusable materials such as roof timber, timber frames, roofing sheets, roofing tiles, structural steel etc not for bricks, blocks or rubble. Hence new concept has to be developed to reduce waste in demolition.

Introduction of "Deconstruction" and promote "Deconstruction" rather than "Demolition"

Deconstruction is nothing new to the demolition industry. Professional demolition contractors provide safe, efficient services for dismantling, materials recovery, and site clearance using deconstruction methods, as well as modern techniques and equipment. Main purpose of deconstruction is to minimize wastage in demolition of structures by carefully removing reusable items. Most of the bricks, blocks and rubble can be separated if proper attention paid. Although this is a labour intensive operation, it will reduce quantity of waste.

Demolition of masonry walls due to design changes of client and consultant Architect is more common in on going projects rather than concrete. To mitigate this kind of waste generation, the designer should convince the client about his final product by real modeling or computer modeling. As discussed earlier there are some computer packages available for computer modeling which can be done at minimal cost. Routing site visits by the client or full time his representative available at site will reduce this kind of conflicts. Most of the time these demolished bricks or blocks are reusable if demolition is done carefully. But contractors are not very much interest about used materials as they are paid for both construction and demolition if any change. As a responsible contractor himself he can subsidize to reduce waste generation by providing additional labour force to deconstruct the wall rather than demolition.

Demolition due to contractor's fault such as incorrect locations, dimensions etc. are more common in low grade contractors due to lack of experienced and qualified staff. In this case

contractor pay more attention to demolish the wall carefully at least to save part of materials been used as to avoid loosing in both construction and demolition.

Most of the main contractors let labour subcontractors to do the masonry walls in piece rate basis providing necessary materials to speed up the job and complete the task within the budget. But subcontractors are interested only speed of the job as they can earn more money. Thus low quality product and high material wastage is more often to be expected in labour subcontracting. Over usage of raw materials can be seen in rubble wall construction than brick or block wall construction under labour subcontract. To reduce this kind of wastage

- Exact quantity of raw materials are to be issued to subcontractor for particular task – this method is more viable when single subcontractor is employed for brick or block works. If more subcontractors are involved, material issue is more complicated and more staff needed for monitoring.
- Penalties to be imposed to subcontractors when low quality product found or any wastage found – this can be implemented easily

Masonry wastage due to accidents is unavoidable and possibility of reuse of materials is minimal but recycling is possible. Rubble scraps can be reused after proper cleaning of debris.

Utilization of unskilled labour for any kind of construction creates more wastage in many ways. Time and material wastage are more important factors to be considered. Low quality output tends to demolition and rework. To mitigate this kind of wastage trained labour force has to be recruited to the projects. As a long term strategy, more training centers are to be instituted by the government and main contractors in their premises to train people and change their attitudes.

Poor storage facilities, excess ordering and bad weather conditions are to be considered in generation of construction waste. Bricks, sand and cement are the more affected materials than rubble or blocks. There are several ways to mitigate this wastage.

- JIT concept in logistic – materials to be reached to the site in correct quantity on correct time(no earlier or no later and no more or no less)
- First come – first out principle
- Providing proper storage for easily deteriorate materials such as cement, bricks, sand etc.

Metal (Ferrous and non ferrous)

Tor steel and mild steel bars use for structural concrete and angle iron, c-channels, H-iron, box iron, roofing sheets etc use for structural steel works are most common ferrous materials in Sri Lankan projects. There are allowable factors of wastage for steel in construction projects. Main sources of waste are

- Off-cuts of tor steel or mild steel, angle iron, c-channel, H-iron pieces which cannot be further used as structural steel due to insufficient length
- Used steel bars from demolished structural concrete due to overage or design changes
- Off – cuts of steel roofing sheets due to various roof shapes and structures not designed for market available sizes

Some professional contractors have already implemented off – cut waste mitigation programs in their projects.

- Use longer steel bars instead of standard market available bars
- Computer programs are available or could be developed in such a way to cut the steel bar without off-cut or least off-cut length.
- Steel fabrication done in central fabrication yard thus the residuals from one project can be used for some other project to minimize wastage. No off-cuts could be found in the site.

Most common non ferrous metals could be found in Sri Lankan projects are aluminium off-cuts from door and window frames, partition walls, copper from wires, stainless steel from railings etc. Fortunately most of our craftsmen are capable to do the fabrication of door and window frames with aluminium with minimal wastage.

All kind of ferrous and non- ferrous metal wastes are collected by nominated subcontractors and send for recycling.

Timber

There are various types of timber waste that could be found in projects such as lumber, treated timber, untreated timber, plywood etc.

In the stage of site clearing, trees within the building area has to be cut and removed and stumps, branches etc will be in the site for a certain period of time. In the Sri Lankan context

coconut stumps are creating more problems in sites as they are too heavy to handle and not possible to use as fire wood. Other type of stumps can be split easily and used as fire wood. All kind of branches can be used as fire wood always. Cutting of trees would generate long term environmental problems in anyway. To avoid generating this kind of waste, NO tree areas can be selected for the building basically and some Architects use to select building area with minimal cutting of trees while protecting natural environment. Mass clearing of coconut lands for buildings has to be stopped by means of imposing government rules and regulations assuming it as a policy matter.

Untreated timber waste such as 4" x 2", 2" x 2", planks etc and treated or untreated plywood waste could be found in super-structure level as they are used for form work of structural concrete. Untreated timber waste will be decomposed or can be used as fire wood material while treated timber gives long term environmental hazards. To reduce this kind of waste, steel or any other metal form work can be introduced like other developed countries are used. Pre-cast concrete elements can be used for the building thus no form work is required.

Treated and untreated timber waste could be found as off-cuts in finishing stage of the project as they are used for roof, door and windows etc. Most of the time roof frames are not designed in accordance with the market available sizes and various shapes of roofs create more waste. Sometimes door and window frames and panes are fabricating at site which generates timber waste including saw dust. To minimize this kind of timber waste generation, door and window frames can be fabricated in central workshop. Alternatives could be used for frames such as aluminium or steel. Most of commercial buildings are designed for steel roof and aluminum frames and thus avoid generation of timber waste.

Plastics (films, containers, PVC products, polyethylene products)

Most of polythene films in sites are identified as packing materials of some other products delivered to the site. As a new concept to the site management and suppliers, a policy could be developed to collect back packing materials by relevant suppliers at the end of work. But this will be much debatable because supplier has to provide additional effort and cost on this. Research has to be carried out to check the feasibility.

PVC containers of paints, powder materials etc. and PVC pipe materials use for plumbing could be found in most of projects as waste. Most of containers are collected by workers to reuse and rest of them can be forwarded to recycling contractors. PVC pipe accessories could be use for temporary works in same project or some other projects. Most of plastic items can be recycled.

Glass

Glasses are mainly used for doors and windows, external wall panels of the building. Most of the time frames are fabricated outside and delivered to the site. Hence glass residuals are very minimal in new construction projects except any accidental damage. But glass waste can be seen in demolition projects. Fortunately all kind of glass can be recycled in Sri Lanka but proper link has to be developed.

Ceramic Tiles

Ceramic tiles are get damaged mainly while transporting and due to poor storage. To achieve some odd shapes in architectural designs, tiles are to be cut to the required shape and balance will be wasted. Some times due to design changes by consultants or clients some floor tiles or wall tiles may have to remove and cannot reuse due to hard cement backing and all may get wasted.

Before tiling commence many approvals are to be taken from client, consultant, main contractor etc such as colour of tile, design of tile, size of tile, orientation, finish level, slope direction etc. Then waste can be minimized.

Most of tile manufactures used to stack tiles in boxes to avoid getting damage parlous road conditions in Sri Lanka but such precautions are not sufficient. To mitigate this kind of damages, transporters are to be advised and impose penalties. Site facilities are to be provided for proper storage of tiles without moving to many locations. Height of stack is to be limited to avoid damages happen to bottom most layers of tiles due to overloading.

4.7.2 Reuse of construction waste

Reuse is second line method in waste management and first method after waste generation. Several researches have been carried out in Sri Lankan research centers and by post graduate students to reuse the C&D waste for other purposes. One important research out put is to suggest the possibility of C&D waste materials to use in the construction of road bases. But there are some drawbacks on this method. Although C&D waste are structurally sound to use for road base, it may contain some hazardous materials such as oil, lubricants, paints, any other chemicals which may be contaminated with ground water. So directly from site to road is not possible and material sorting has to be done.

If brick or block walls can be demolished carefully, those materials can be reused for some other construction work. It is not easy task, time consuming and labour intensive but materials are reusable. Rubble waste from walls and foundations can be easily separated from mortar and other debris and can be reused.

There are some wastes collected as residuals at the work place of construction of brick or block walls, plastering. It is a mix of brick or block pieces and cement mortar. All waste can be collected at the end of the day and separated brick pieces as much as possible. Block pieces can be crushed further with a hammer. Then collected waste and crushed blocks can be sieved to remove debris and balance could be used as sand for non structural construction elements such as plaster, wall construction etc. This is a good practice can be implemented easily and some project managers have already implemented this practice.

Broken ceramic tiles collected as waste could be used for decorative floor finishes with various colours in walkways, common areas, parking areas, garages etc. This kind of reuse method can be implemented with the assistance of consultants and architects.

Most of timber frames, roof timber etc of demolished buildings can be reused for similar purpose or as an antique material. Timber form work materials used for structural concrete could be reused many times and finally used as firewood. Asbestos sheets, roof tiles from demolished sites can be reused for any other construction or temporary buildings.

Further researches to be carried out to find more ways of re-use C&D waste materials for other purposes.

4.7.3 Recycle of construction waste

Most of developed countries are practiced various recycling processes for various C&D waste items. We can adopt some of them with some modifications to suit to Sri Lankan environment. Further researches are to be carried out to find suitable recycling processes for C&D waste in Sri Lanka.

Some of waste items such as glass, plastics, packing materials, steel scraps, other metals etc which lead to environmental pollution can be recycled in Sri Lanka. Ceramic tiles are not possible to recycle because producer has a fear of degrading quality if they are used for same purpose. But they can be crushed and use as aggregate for some other purpose.

Most of the concrete batching plants in Singapore have been calculated their wastage as 2-3% and to reduce this waste, they have fixed concrete recycling plants in the premises. Those recycled materials are again used as raw materials. This can be adopt easily if the concrete are not contaminate with other impurities such as bricks, lime, paints, oil, chemicals etc. But concrete waste from projects are always a mix of above impurities and sorting has to be done before feeding to recycle plants.

After the Tsunami disaster in 2004 December in Sri Lanka, a massive quantity of C&D waste found in affected areas. COWAM project described in chapter 2 was launched as a solution for this waste.

Holcim-gtz (2007) research report on "Reuse and Recycling of construction and demolition waste" is summarized the usage of C&D waste as follows.

Table 4.7.3 – Summary of C&D waste reuse, recycle and usage (Holcim-gtz, 2007)

Material	Process	End use
Plain concrete	Crushed	Aggregate
Fresh concrete	Washed to remove cement to recover aggregate	Aggregate
Reinforced concrete	1. Crushed and steel bars removed 2. Steel recycled	1. Crushed concrete reused as aggregate 2. New reinforcement steel
Clay bricks and roof tiles	1. Cleaned 2. Crushed 3. Pulverized	1. Reused for masonry 2. Aggregate 3. Mixed with lime to produce Mortar
Natural stone masonry	1. Cleaned 2. Crushed	1. Reused for masonry 2. Aggregate
Ceramic tiles	1. Cleaned 2. Crushed	1. Flooring, cladding 2. Aggregate
Asphalt paving	1. Crushed and cold-mixed 2. Crushed and hot-mixed	1. Road base, fill material 2. Road construction
Steel	1. Cleaned 2. Recycled	1. Reused steel components 2. New steel components
Timber beams, doors, etc.	Cleaned	Reused as beams, doors, etc.
Timber boards	Cleaned	1. Reused as shuttering and other products 2. Feedstock for engineered Woods
Timber (miscellaneous items)	1. Cut to suitable sizes 2. Chipped	1. Firewood, co-processing 2. Landscape mulch, soil conditioner, boiler fuel, etc.
Plastics	Recycled	New products
Gypsum plasterboard	1. Cleaned 2. Crushed 3. Recycled	1. Reuse as boards 2. Soil conditioner 3. New gypsum products
Glass	1. Cleaned 2. Crushed 3. Recycled	1. Reused for windows, mirrors, etc. 2. Aggregate 3. New products
Electrical and sanitary fixtures	1. Clean 2. Separate unusable items into individual components to facilitate recycling	1. Reuse 2. New products
Insulation	1. Clean 2. Recycle	1. Reuse 2. New products
Packaging materials	Recycle	New packaging material

4.8 Proposed Guide lines to develop rules and regulations for C&D waste Management

Table 4.8 – Proposed guide lines for respective parties to prepare rules and regulations for C&D waste management

	Guide lines	**Responsible**
1	Waste management plan to submit with building application	Local Authority
2	Waste collecting contractors / demolition contractor to registered in local authority and CEA	Local Authority / CEA
3	Each and every contractor should have their own strategies for waste management and to produce in registration	Contractors / ICTAD
4	Illegal low land fillings to stop	Local Authority
5	Establish a model recycling plant within the Colombo	CEA
6	Revision of building material standards and specifications	ICTAD/ IESL/ SLS
7	New rules and regulations for C&D waste management	CEA
8	Find a market for recycled products	CEA
9	Qualified and experienced Architects and Engineers to practice as Consultants in projects	IESL / IASL
10	Training of site personnel regarding C&D waste management	Contractor
11	Responsible person from contractor to appoint for waste monitoring at site level	Contractor
12	Waste audit report to submit to CEA in every month	Contractor
13	Use contractors waste audit reports to prepare proper C&D waste management plan	CEA

4.9 Summary

There are various types of C&D waste items in different quantities which are generated in sites in various stages of the project. Each and every waste item has an economical value regardless of its volume. Main objective of this research is to find out main C&D waste items and their causes and finally how to reduce waste generation. There are mainly six causes for C&D waste generation identified in Sri Lankan projects such as due to design errors and design changes, procurement errors, improper handling of materials, operation errors, residuals and bad weather conditions. These causes are influenced in different levels in 3 main stages of a project.

Table 4.9 – Significant causes for waste in construction stages

Stage of construction	Significant causes for waste
Sub-structure level	Bad weather condition
Super-structure level	Procurement errors Design changes
Finishing stage	Design changes

In addition to these main causes grade of contractor, status (semi-government or private) of contractor, project duration, experience of site personnel etc also affect to the C&D waste generation. Most of site personnel and relevant government authorities in Sri Lanka do not realized the importance of C&D waste management system because it has not become a severe socially affected problem as garbage. But most developed countries realized the long term damage caused by C&D waste to the environment and proper management system is always in line with the project progress which included design stage management, pre-construction management and post-construction management. Implementation of 3R can be assumed as best practice for C&D waste management in Sri Lankan context. Waste reduction or waste minimization is more important than re-use or recycling because it gives more economical and social benefits to the organization and environment too.