Experimental Investigation Of Using Concrete Waste And Brick Waste As A Coarse Aggregate

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ABSTRACT

To generate a study on concrete which incorporate Over Burnt Brick Ballast and concrete waste partially due to their abundance. 25%, 50% (M15, M25) incorporation was used as partial replacement of natural coarse aggregate in concrete. Analysis of incorporated concrete was done in fresh state as well in hardened state to evaluate different properties of concrete i.e. slump, compaction factor test, unit weight, and compressive strength are evaluated. From all the results and experimental approach it is concluded that Concrete formed with over burnt brick ballast and concrete waste aggregate showed beneficial performance as compared with the concrete made up of natural aggregate obtained from local resources. It reduces the cost of concrete by reducing the aggregate cost and produces economical infrastructure system. It has been observed that the use of waste materials results in the formation of light weight concrete. Uses of such waste materials will not only cut down the cost of construction, but will also contribute in safe disposal of waste materials. Apart from the environmental benefits, the addition of such wastes, also improves certain properties of resultant concrete. Cubes of concrete were prepared and tested to study the compressive strength. The results were compared with concrete made with river wash gravel as coarse aggregates which at present is the only coarse aggregate. It can be concluded that by reducing the water-cement ratio from 0.60 to 0.40 the compressive strength of crushed over burnt bricks - sand concrete and gravel - sand concrete increase by more than 30%. Use of broken over burnt bricks as coarse aggregate for structural concrete is recommended when natural aggregate is not easily available, high strength of concrete is not required and the bearing capacity of the soil is low.

Keywords: Experimental, Investigation, Concrete Waste, Brick Waste, Coarse Aggregate

1.INTRODUCTION

1.1 General

As the time is passing, the construction industry is growing rapidly and in the last decade we are seeing relatively huge constructions. With this rapid growth, a concern of its waste management also growing with the same speed every annum. This problem is not of some specific region but it is a global problem and raising his head high very fast. Dozens of materials are common in the construction industry and one of the materials is brick. Regular bricks are used in the construction of buildings either as main walls, partition walls or some other purposes. When we see the perspective of its manufacturing we find a lot of waste in the form of over burnt bricks. In every batch of brick manufacturing, a high number of over burnt bricks are produced which acts as a waste. (Recycling is a process to change materials (waste) into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution (from land filling) by reducing the need for "conventional" waste disposal, and lower greenhouse gas emissions as compared to plastic production). The brick which are near the fire in the kiln subjected to high heat more than 1000 degree centigrade. Ultimately shrink and loose its shape, color becomes redish and its appearance like redish to blackish gradient stone. This over burnt brick serves as waste in the construction industry and has to accumulate somewhere in the process of recycling. Concrete is a solid, hard material produced by combining Portland cement, coarse and fine aggregate (sand & stone), water and sometimes admixtures in proper proportions. It is one of the most widely used construction material and has a long history of use. Its constituent ingredients derive from a wide variety of naturally occurring materials that are readily available in the most parts of the world. Approximately 60 to 80 percents of concrete is made up of aggregates. The cost of concrete and its properties are directly related to the aggregates used. In aggregates, the major portion is of coarse aggregate i.e. stone or gravel which are obtained naturally either from river bed or by crushing rocks mechanically up to the required size. According to general definition concrete is a composite material so by taking advantage of the situation for the people, this paper presents the overview and research that is carried out on the concrete when natural coarse aggregate is partially replaced by over burnt brick aggregate. No construction activity can be imagined without using concrete. Concrete is the most widely used building material in construction industry. The main reason behind its popularity is its high strength and durability. Today, the world is advancing too fast and our
environment is changing progressively. This has created what we call the biggest problem of the world, industrial waste and debris accumulation. Hence there is a need to recycle these waste into something more useful and environment friendly. To achieve this, major emphasis must be laid on the use of waste from various industries. Research into new and innovative use of waste materials being undertaken world-wide and innovative ideas that are expressed are worthy of this important subject. Research concerning the use of by-products to augment the properties of concrete has been going on for many years. Many highway agencies, private organizations and individuals have completed or are in the process of completing a wide variety of studies and research projects concerning the feasibility, environmental suitability and performance of using waste materials in construction. The potential applications of industry by-products in concrete are as partial aggregate replacement or as partial cement replacement, depending on their chemical composition and grain size. The use of these materials in concrete comes from the environmental constraints in the safe disposal of these products. These studies try to match societal need for safe and economic disposal of waste materials with the help of environmental friendly industries, which needs better and cost-effective construction materials.

1.2 Objective
The main objective of the research project is to determine the properties of concrete by replacing natural coarse aggregate with over burnt brick ballast aggregate and concrete waste. Different tests were carried out on fresh concrete. Four batches of concrete incorporating over burnt brick ballast aggregate and concrete waste aggregate were prepared. The replacement was 25%, 50% represented as M15, M25 and respectively. Here M denotes the concrete mix and subscript designates the percentage replacement by natural coarse aggregate to over burnt brick ballast aggregate.

2. MATERIALS USED
In this project waste materials were utilized to produce building bricks. The following materials were used in this investigation.

2.1 Cement
Cement is one of the binding materials in this project. Cement is the important building material in today’s construction world. 53 grade Ordinary Portland Cement (OPC) conforming to IS: 8112-1989. Ordinary Portland cement, 53 Grade conforming to IS: 269 – 1976. Ordinary Portland cement, 53 Grade was used for casting all the specimens. Different types of cement have different water requirements to produce pastes of standard consistence. Different types of cement also will produce concrete have a different rate of strength development. The choice of brand and type of cement is the most important to produce a good quality of concrete. The type of cement affects the rate of hydration, so that the strengths at early ages can be considerably influenced by the particular cement used. It is also important to ensure compatibility of the chemical and mineral admixtures with cement.

2.2 Fine Aggregate
Locally available river sand conforming to Grading zone II of IS: 383 –1970. Clean and dry river sand available locally will be used. Sand passing through IS 4.75mm Sieve will be used for casting all the specimens.

2.3 Coarse Aggregate
Crushed granite aggregate with specific gravity of 2.77 and passing through 4.75 mm sieve and will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability. Locally available crushed blue granite stones conforming to graded aggregate of nominal size 20 mm as per IS: 383 – 1970. Crushed granite aggregate with specific gravity of 2.77 and passing through 4.75 mm sieve and will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

2.4 Brick Ballast
These are the broken brick parts/remains obtained from well burnt bricks. It is made free of dust before use.

Used:
- Where natural aggregate is expensive
- Where natural aggregate is not available
- Thoroughly saturated ballast is used in concrete.
2.5 Concrete Waste

Recycling is the act of processing the used material for use in creating new product. The usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement materials. Recycled aggregate are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. These materials are generally fromTo achieve this, major emphasis must be laid on the use of wastes and byproducts in cement and concrete used for new constructions. The utilization of recycled aggregate is particularly very promising as 75 per cent of concrete is made of aggregates. In that case, the aggregates considered are slag, power plant wastes, recycled concrete, mining and quarrying wastes, waste glass, incinerator residue, red mud, burnt clay, sawdust, combustor ash and foundry sand. The enormous quantities of demolished concrete are available at various construction sites, which are now posing a serious problem of disposal in urban areas.(Figure.2.1)

![Concrete Waste](image)

Figure.2.1: Concrete Waste

2.6 Water

Casting and curing of specimens were done with the potable water that is available in the college premises.

3.MATERIAL CHARACTERISTICS

3.1 Cement

The type of cement used was Portland Pozzalona Cement.

3.1.1 Specific Gravity

The density bottle was used to determine the specific gravity of cement. The bottle was cleaned and dried. The weight of empty bottle with brass cap and washer was taken. Then bottle was filled by 200 to 400g of dry cement and weighed as \( W_1 \). The bottle was filled with kerosene and stirred thoroughly for removing the entrapped air which was weighed as \( W_2 \). It was emptied, cleaned well, filled with kerosene and weighed as \( W_4 \).

3.1.2 Fineness (By Sieve Analysis)

The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Finer cement offers a greater surface area for hydration and hence faster development of strength. 100 grams of cement was taken on a standard IS SieveNo.9(90 microns). The air-set lumps in the sample were broken with fingers. The sample was continuously sieved giving circular and vertical motion for 15 minutes. The residue left on the sieve was weighed.

3.1.3 Consistency

The objective of conducting this test is to find out the amount of water to be added to the cement to get a paste of normal consistency. 500 grams of cement was taken and made into a paste with a weighed quantity of water (% by weight of cement) for the first trial. The paste was prepared in a standard manner and filled into the vicat mould plunger, 10mm diameter, 50mm long and was attached and brought down to touch the surface of the paste in the test block and quickly released allowing it to sink into the paste by its own weight. The depth of penetration of the plunger was noted. Similarly trials were conducted with higher water cement ratios till such time the plunger penetrates for a depth of 33-35mm from the top. That particular percentage of water which allows the plunger to penetrate only to a depth of 33-35mm from the top

3.1.4 Initial Setting Time

The needle of the Vicat apparatus was lowered gently and brought in contact with the surface of the test block and quickly released. It was allowed to penetrate into the test block. In the beginning, the needle completely pierced through the test block. But after sometime when the paste starts losing its plasticity, the needle penetrated only to a depth of 33-35mm from the top. The period elapsing between the time when water is added to the cement and the time at which the needle penetrates the test block to a depth equal to 33-35mm from the top was taken as the initial setting time.
3.2 Coarse Aggregate
20mm down size aggregate was used.

3.2.1 Specific Gravity
A pycnometer was used to find out the specific gravity of coarse aggregate.

3.2.2 Bulk Density
Bulk density is the weight of a material in a given volume. It is expressed in Kg/m³. A cylindrical measure of nominal diameter 250mm and height 300mm was used. The cylinder has the capacity of 1.5 liters with the thickness of 4mm. The cylindrical measure was filled about 1/3 each time with thoroughly mixed aggregate and tampered with 25 strokes. The measure was carefully struck off level using tamping rod as straight edge. The net weight of aggregate in the measure was determined. Bulk density was calculated as follows.

\[ \text{Bulk density} = \frac{(\text{Net weight of coarse aggregate in Kg})}{(\text{Volume})} \]

3.2.3 Surface Moisture
100g of coarse aggregate was taken and their weight was determined, say W₁. The sample was then kept in the oven for 24 hours. It was then taken out and the dry weight is determined, says W₂. The difference between W₁ and W₂ gives the surface moisture of the sample.

3.2.4 Water Absorption
100g of nominal coarse aggregate was taken and their weight was determined, say W₁. The sample was then immersed in water for 24 hours. It was then taken out, drained and its weight was determined, says W₂. The difference between W₁ and W₂ gives the water absorption of the sample.

3.2.5 Fineness Modulus
The sample was brought to an air-dry condition by drying at room temperature. The required quantity of the sample was taken (3Kg). Sieving was done for 10 minutes. The material retained on each sieve after shaking, represents the fraction of the aggregate coarser then the sieve considered and finer than the sieve above. The weight of aggregate retained in each sieve was measured and converted to a total sample. Fineness modulus was determined as the ratio of summation of cumulative percentage weight retained (F) to 100.

3.3 Properties Of Concrete Waste
The crushing characteristics of hardened concrete are similar to those of natural rock and are not significantly affected by the grade or quality of the original concrete. Recycled concrete aggregates produced from all but the poorest quality original concrete Recycled concrete aggregates contain not only the original aggregates, but also hydrated cement paste. This paste reduces the specific gravity and increases the porosity compared to similar virgin aggregates. Higher porosity of RCA leads to a higher absorption. In terms of composition, recycled aggregates, obtained from crushed waste concrete, consist of original aggregates and adhered mortar. Two factors which need to be taken into consideration in the use of these recycled materials in the production of new concrete is their structural behavior and durability. It is the percentage of recycled aggregate used, which influences the structural behavior of the new concrete. Also, durability of the recycled aggregate concrete depends on the heterogeneity of the recycled particles. Hence it is important to identify the mechanical, physical and chemical properties of the original coarse aggregates, as well as the original fine aggregates present in adhered mortar, to understand their suitability in the production of recycled concrete. The research involved experiments to analyze the structural behavior of recycled aggregate concrete, using different percentages of recycled aggregates. Construction and demolition waste control becomes indispensable from the moment that statistics refer to the waste’s volume approaching an unsustainable level. The utilization of waste material as secondary raw material is the solution to the problem of an excess of waste material, not forgetting the parallel trend of improvement of final product quality. A systematic use of waste materials involves the classification of the mentioned waste materials according to their strength capacity, durability and utility. The basic components obtained from construction and demolition waste in concrete, masonry and mortar. Secondary raw aggregates are obtained from the waste crushed concretes. From a quality point of view, the original aggregates are heterogeneous in composition being derived from different minerals and adhered mortar. Primary raw coarse aggregate (granite) and sand (crushed limestone) were used indifferent concrete mixes.

3.4 Properties Of Water
Water used for mixing and curing shall be clean and free from injurious amounts of Oils, Acids, Alkalis, Salts, Sugar, Organic materials Potable water is generally considered satisfactory for mixing concrete. Mixing and curing with sea water shall not be permitted. The pH value shall not be less than 6.

3.5 Fresh Concrete Properties
3.5.1. Workability
With the addition of furnace slag, the slump loss with time is directly proportional to increase in the slag content due to the introduction of large surface area in the concrete mix by its addition. Although the slump decreases, the mix remains highly cohesive.
3.5.2 Segregation And Bleeding
Furnace slag reduces bleeding significantly because the free water is consumed in wetting of the large surface area of the furnace slag and hence the free water left in the mix for bleeding also decreases. Furnace slag also blocks the pores in the fresh concrete so water within the concrete is not allowed to come to the surface.

3.5.3 Slump Test
Fresh concrete when unsupported will flow to the sides and sinking in height will take place. This vertical settlement is known as slump. (Figure 3.1)

- The workability (ease of mixing, transporting, placing and compaction) of concrete depends on wetness of concrete (consistency) i.e., water content as well as proportions of fine aggregate to coarse aggregate and aggregate to cement ratio.
- The slump test which is a field test is only an approximate measure of consistency defining ranges of consistency for most practical works. This test is performed by filling fresh concrete in the mould and measure the settlement i.e., slump.

![Figure 3.1: Slump Test](image)

3.6 Hardened Concrete Properties
3.6.1 Compression Test On Concrete Cubes
The determination of the compressive strength of concrete is very important because the compressive strength is the criterion of its quality. Other strength is generally prescribed in terms of compressive strength. The strength is expressed in N/mm². This method is applicable to the making of preliminary compression tests to ascertain the suitability of the available materials or to determine suitable mix proportions. The concrete to be tested should not have the nominal maximum size of aggregate more than 20mm test specimens are either 15cm cubes or 15cm diameter used. At least three specimens should be made available for testing. Where every cylinder is used for compressive strength results the cube strength can be calculated as under. Minimum cylinder compressive strength = 0.8 x compressive strength cube (10 cm x 10 cm) The concrete specimens are generally tested at ages 7 days and 28 days.

3.6.2 Split Tensile Test On Cylinder
Concrete is strong in compression but weak in tension. Tension stresses are likely to develop in concrete due to drying shrinkage, rusting of reinforcement, temperature gradient etc. In concrete road slab this tensile stresses are developed due to wheel loaded and volume changes in concrete are available to determine this. Split test is one of the indirect methods available to find out the tensile strength.

3.6.3 Flexural Test On Beams
It is the ability of a beam or slab to resist failure in bending. It is measured by loading un-reinforced 6x6 inch concrete beams with a span three times the depth (usually 18 in.). The flexural strength is expressed as “Modulus of Rupture” (MR) in psi. Flexural MR is about 12 to 20 percent of compressive strength.

4. MIX DESIGN
4.1 Definition
Mix design is the process of selecting suitable ingredient if concrete and determines their relative proportions with the object of certain minimum strength and durability as economically as possible.

4.2 Objective Of Mix Design
The objective of concrete mix design as follows.
- The first objective is to achieve the stipulated minimum strength.
- The second objective is to make the concrete in the most economical Manner. Cost wise all concrete’s depends primarily on two factors, namely cost of material and cost of labour. Labor cost, by way of formwork, batching, mixing, transporting and curing is namely same for good concrete.

4.3 FACTORS TO BE CONSIDERED IN MIX DESIGN
1. Grade of concrete
2. Type of cement
3. Type & size of aggregate
4. Type of mixing & curing

5. Water /cement ratio
6. Degree of workability
7. Density of concrete
8. Air content

5. TESTING PROCEDURE

5.1 Compressive Strength Test
When a specimen of material is loaded in such a way that it extends it is said to be in tension. On the other hand if the material compresses and shortens it is said to be in compression. On an atomic level, the molecules or atoms are forced apart when in tension whereas in compression they are forced together. Since atoms in solids always try to find an equilibrium position, and distance between other atoms, forces arise throughout the entire material which oppose both tension and compression. The phenomena prevailing on an atomic level are therefore similar. (Figure 3.1). The "strain" is the relative change in length under applied stress; positive strain characterises an object under tension load which tends to lengthen it, and a compressive stress that shortens an object gives negative strain. Tension tends to pull small sideways deflections back into alignment, while compression tends to amplify such deflection into buckling. Compressive strength is measured on materials, components, and structures. By definition, the ultimate compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of a compressive test. The apparatus used for this experiment is the same as that used in a tensile test. However, rather than applying a uniaxial tensile load, a uniaxial compressive load is applied. As can be imagined, the specimen (usually cylindrical) is shortened as well as spread laterally. At the time of testing, each specimen must keep in compressive testing machine. The maximum load at the breakage of concrete block will be noted. From the noted values, the compressive strength may calculated by using below formula.

\[
\text{Compressive Strength} = \frac{\text{Load}}{\text{Area}}
\]

Size of the test specimen=150mm x 150mm x 150mm

Figure 5.1 Compression Test

5.2 Split Tensile Test
The size of cylinders 300 mm length and 150 mm diameter are placed in the machine such that load is applied on the opposite side of the cubes are casted. Align carefully and load is applied, till the specimen breaks. The formula used for calculation.

\[
\text{Split tensile strength} = \frac{2P}{\mu dl}
\]

Figure 5.2 Split Tensile Test
The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure. (Figure 5.2). Apart from the flexure test the other methods to determine the tensile strength of concrete can be broadly classified as (a) direct methods, and (b) indirect methods. The direct method suffers from a number of difficulties related to holding the specimen properly in the testing machine without introducing stress concentration, and to the application of uniaxial tensile load which is free from eccentricity to the specimen. As the concrete is weak in tension even a small eccentricity of load will induce combined bending and axial force condition and the concrete fails at the apparent tensile stress other than the tensile strength. As there are many difficulties associated with the direct tension test, a number of indirect methods have been developed to determine the tensile strength. In these tests in general a compressive force is applied to a concrete specimen in such a way that the specimen fails due to tensile stresses developed in the specimen.

The splitting tests are well known indirect tests used for determining the tensile strength of concrete sometimes referred to as split tensile strength of concrete. The test consists of applying a compressive line load along the opposite generators of a concrete cylinder placed with its axis horizontal between the compressive platens. Due to the compression loading a fairly uniform tensile stress is developed over nearly 2/3 of the loaded diameter as obtained from an elastic analysis. The magnitude of this tensile stress \( \sigma_{Sp} \) acting in a direction perpendicular to the line of action of applied loading is given by the formula (IS : 5816-1970):

\[
\text{The ratio of the split tensile strength to cylinder strength not only varies with the grade of the concrete but is also dependent on the age of concrete. This ratio is found to decrease with time after about a month. The air-cured concrete gives lower tensile strength than that given by moist-cured concrete. The flexural strength as obtained by rupture test is found to be greater than the split tensile strength. This test is becoming very popular because of the following advantages, viz.,}
\]

i) The test is simple to perform and gives more uniform results than that given by other tests.

ii) The strength determined is closer to the actual tensile strength of concrete than the modulus of rupture value.

iii) The same moulds and testing machine can be used for compression and tension tests

5.3 Flexural Strength Test

During the testing, the beam specimens of size 700mmx150mmx150mm were used. Specimens were dried in open air after 7 days of curing and subjected to flexural strength test under flexural testing assembly. Apply the load at a rate that constantly increases the maximum stress until rupture occurs. The fracture indicates in the tension surface within the middle third of span length

Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, is a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. The flexural strength would be the same as the tensile strength if the material were homogeneous. In fact, most materials have small or large defects in them which act to concentrate the stresses locally, effectively causing a localized weakness. When a material is bent only the extreme fibers are at the largest stress so, if those fibers are free from defects, the flexural strength will be controlled by the strength of those intact 'fibers'. However, if the same material was subjected to only tensile forces then all the fibers in the material are at the same stress and failure will initiate when the weakest fiber reaches its limiting tensile stress. Therefore it is common for flexural strengths to be higher than tensile strengths for the same material. Conversely, a homogeneous
material with defects only on its surfaces (e.g., due to scratches) might have a higher tensile strength than flexural strength.

6. TEST RESULT

6.1 Various Percentage Of Concrete Waste & Brick Waste

6.1.1 For M15 Grade Concrete

Ratio –I

Concrete waste – 50 % by replacement of Coarse Aggregate

Ratio - ii

Brick – 50 % by replacement of Coarse Aggregate

6.1.2 For M25 Grade Concrete

Ratio –I

Concrete waste – 25 % by replacement of Coarse Aggregate

Ratio - ii

Brick – 25 % by replacement of Coarse Aggregate

Table 6.1 shows Compressive Test For Cube at 7 Days, Table. 6.2 shows Compressive Test For Cube at 14 Days, Table 6.3 shows Compressive Test For cube at 28 Days, Table 6.4 shows Split Tensile Test For Cylinder at 7 days, Table 6.5 shows Split Tensile Test For Cylinder at 14 Days, Table 6.6 shows Split Tensile Test For Cylinder at 28 Days, Table 6.7 shows Flexural Strength Test For beam at 7 Days, Table 6.8 shows Flexural Strength Test For beam at 14 Days and Table 6.9 flexural strength test for beam at 28 days.
7. CONCLUSIONS

The conclusions drawn from these experimental investigations are as follows.

- Use of waste materials results in the formation of lightweight concrete.
- Use of such waste materials not only cuts down the cost of construction, but also contributes in safe disposal of waste materials.
- The strength of the concrete is found out to the M15 & M25 concrete.
- Compressive strength of concrete is high when containing concrete waste 50% in concrete.
- The strength of concrete containing concrete waste of 50% was high compared with that of the conventional mix and also compared with M15 mix design concrete.
- From the present experimental investigation it was found that the recycled aggregates will influence much in hardened properties of concrete. As the percentage of crushed concrete coarse aggregates and crushed brick fine aggregates is increased,
- Coarse aggregate is replacement level of 25% & 50% brick waste in concrete mixes was found to be the level to obtain higher value of the strength and durability at the age of 28 days.
- 25% & 50% concrete waste in concrete mixes was found higher value of the strength compared with brick waste used in concrete.
- Finally conclude the compressive strength, flexural & split tensile strength was high when containing concrete waste 50% in concrete compared with M15 and brick waste used in concrete.

REFERENCES

[7]. Saha, Nabanita, Mukhopadhya, Satyanarayan, Siddique, Imran and Saha, Petr (2005), “Waste leather in India – An integrated business with value creation opportunities”, 7th World Congress on Recovery, Recycling and Re-integration (RnR05) in Beijing, China.


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