Advanced Topics in Science and Technology of Concrete
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Recycled Concrete Aggregate (RCA): Availability, Collection, and Processing Methods – Part 1

Hello friends, My name is Surendra Singh, and I am an assistant professor in the Department of Civil Engineering at IIT Madras, India. Today we will be going to discuss a very important topic with respect to C&D waste: how much of the C&D waste is available, how it is generated and today we will be going to discuss a very important topic with respect to C&D waste, that is how much of the C&D waste is available and how it is generated as well as collected from different parts and what are the various preliminary processing techniques that are usually adopted in order to extract recycled concrete aggregates. So, from here onwards, I will be using the terminology of RCA, which stands for Recycled Concrete Aggregates. So, before going towards the recycled concrete aggregates, let us discuss how the natural aggregates are produced because the production of recycled concrete aggregate is quite similar to the natural aggregates. So, as you can see in the pictures, the generation of the natural aggregates will first go to the mountains, and then we will put some detonators, and then the blast will happen, leading to the generation of the big size boulders. So, it is very difficult to transport these big size boulders directly to the crushing units because the volume occupied by the big size boulders will be higher. So, therefore, the size reduction will be done at the site itself with the help of different techniques.

So, in this picture, you can see they are using normal excavator only in order to reduce the size. So, let us say the big boulder size is 1 to 2 meters. Then, these techniques will be able to reduce the size to around 600 to 700 mm, and thereby, the small size of the boulders will be transported to the crushing units, wherein the resizing will be done in order to get the different sizes of the coarse natural aggregates. So, as far as the fine aggregates are concerned, normally, you know, river sand was traditionally used. So, as we know, rivers will be having a lot of sediment, and then, wherever the level of the water is lower, with the help of the excavators, the river sand can be extracted.

But right now, if you see all around the globe, there is a quite scarcity of the river sand. So,

therefore, now the industries have started using crescent, which is nothing, but when these big size boulders are crushed into small sizes, the size can be further reduced to below 4.75 or 4.5 mm, and then that crescent can be used instead of the river sand. So, let us see how what the total consumption of the natural aggregates globally.

So, in 2015, the total worldwide demand for the natural aggregates was around roughly around 50 billion tonnes per year, if we compare with the previous data. So, you can see every 5 years, the demand increases by roughly by 10 billion tonnes, and it is predicted that in the next 2 to 3 decades, the demand for natural aggregates will be increased by 2 to 3 folds. That means a significant quantity of the natural aggregates will be required in the future. So, do we have that much of you know supply of natural aggregates for meeting our demands? Let us see. So, this is the data from India.

So, here you can see that the demand for river sand is around 751 million tonnes per annum. But, however, in India, because of the many reasons, particularly negative effect on the environment, the mining of the river sand is banned in most parts of the country. So, that means the only alternative is to use the crust sand. So, if we see the demand for crushed stones for both for natural coarse aggregate and natural fine aggregate is around 1.6 billion tonnes per annum and we have sufficient supply of around 126 billion tonnes.

A similar figure can be seen for limestone, wherein the demand is 320 million tonnes per annum and the supply or the reservoir available is 89.3 billion ns. But it should be noted that most of this reservoir is in restricted areas. For example, reserve forests where we cannot do the mining. That means if we keep the rate of production and consumption of these materials to be constant for next 30 to 50 years, or 40 to 80 years, you will see that after 80 years, there will not be no supply of any reservoir available for natural aggregate.

That means this is the right time and high time to look for the alternative supply for the natural aggregates. And one of the promising aggregates that can be used in the construction industry is C&D waste. So, here C means construction and D means demolition waste. So, how much of the C&D waste is available? So, globally, if you see China producing a significant quantity of the C&D waste, followed by the US, India, and France,. But the moment you change the literature, you will see there will be difference in the quantity of the C&D waste that has been reported.

For example, here, the total C&D waste generated by China is around 2.4 billion tonnes per year, and wherever in this literature, it has been reduced by 50 percent. A similar scenario can be seen for India. So, in India, we have data from different agencies from different academicians and researchers, and you can see that the quantum of the C&D waste is varying from 10 million tonnes per annum to, in fact, 714 million tonnes per annum. That means there is a huge difference in the reported values.

And obviously, for materials like C&D waste, there will always be differences because of multiple reasons, and some of the reasons are, for example, that around 35 percent of all the total C&D waste around 35 percent is in landfills. And then, most of the time, the C&D waste will be mixed with the municipal solid waste, and then it will be very difficult to track it down. And also, there are many incidents; in fact, in most of the cases that we have seen, the C&D waste will be illegally dumped for multiple reasons. Maybe let us suppose the dumping site is here and then it is very far from the source of the C&D waste or the charges of the landfilling is very very high. So, in most of the cases that we have seen, illegal dumping is being carried out, and then it is covered with the soil so that nobody will be able to see.

And obviously, there is no proper inventory with respect to the C&D waste. So, therefore, the experts who are working on the C&D waste think that the total quantity or the reported quantity of the C&D waste is highly underestimated, and therefore proper mapping of the C&D waste is required. So, out of all the human waste, or, you can say, the waste that is generated due to the human activities, around 30 to 35 percent is the construction and demolition waste. Although this data is for European Union, a similar figure can be seen for different countries, with a little bit here and there and some tweaks. So, if we see the composition of the C&D waste, it consists of different materials.

For example, if we are demolishing a building, we will obviously be getting bricks and machineries and also we will be getting concrete from slabs, beams, and columns. And in case if you are demolishing the pavements from there, we can get the soil, sand, and gravel, and obviously we use steel, we use wood for doors and windows, and then bitumen, and also there will be some other organic impurities in the C&D waste. So, let us say a C&D waste is coming. It will be having all these materials, and when we crush it into small sizes, the

aggregates that will be generated will be called as recycled aggregates. The quality of the recycled aggregates has been seen to be very inferior to natural aggregates, but however if we crush only this concrete portion and then resize it, the material will be called as recycled concrete aggregate, that is our RCA. So, the quality of the RCA has been seen to be significantly better than the recycle aggregate because recycle aggregate is a mixture of different components, but however if we demolish a building, you know obviously some other impurities will always be there.

But however, we have the avenues from which pure recycled concrete aggregates can be extracted, for example, pavements. So, in pavements, if I talk about the concrete pavements, which are used for, you know, major highways, they will be having two layers of the concrete, pure concrete. So, the top layer, which is called as the wearing course, and then the bottom layer, which is or the subsequent layer, which is called the base course layer. So, here we use the concrete from M30 grade to M50 grade, and then in the base course we use the concrete of M10 to M20 grade. So, similarly, pure concrete chunks can be extracted from pile caps and also from the construction waste because, what happens you know, some of the material which is not used then in the transit trucks or during construction, from there also pure recycled concrete aggregates can be extracted.

It shall also be noted that when the concrete unused concrete is in frustration, So, immediately washing it with water will be able to give us pure aggregates out of it. But once it is set down, we have to obviously demolish it in order to get the recycled concrete aggregates. Now, let us see how the you know C&D waste is collected. So, you know, this is a typical example of chaining with the same methodology. You know, similar methodologies are followed for different parts of the country as well as globally also you can see a similar methodologies will be followed.

So, chaining is divided into around 25 zones right based on the population and the other parameters. So, every zone or two zones will at least be having one designated area wherein you know the C&D waste that will be generated will be sent to here. So, these zones will be sorry; these areas wherein the C&D waste will be stored are called as primary collection areas right. So, when the building or when your infrastructure is getting demolished, the owners can directly, you know, send the material there, or they at least in Chennai, they can call municipal corporation and they will come, and then they will correct the C&D waste and

it will be kept at the primary collection unit. And then thereafter, when the quantum of the C&D waste is higher in the primary collection zone, it will be transferred to the secondary collection area right.

And from there, when the quantity of the C&D waste is higher in secondary collection area, it will be transferred directly to the recycling plant. So, the various activities that happens during the you know at these transfer stations are the segregation of the waste. So, normally, what happens is that we see a lot of you-know-materials, apart from the you-know-aggregates that will be there that can be resold. So, will be removed at these transfer stations. But even before you know doing the segregation, segregation will be discussed in the subsequent slides.

So, before even doing the segregation—in fact, before even demolition and rebuilding—some of the material that will be having high cell-base values will be removed. For example, there is a huge scarcity of the wood right good-quality of the wood. So, and then wood the doors, and, you know, other things can be resold. So, because of the high cell base values, doors and windows will be removed right. Similarly, you know the sheets asbestos sheets that we use for the roofing purposes; if they are incorrect, they will also be removed, and they can be resold.

Similarly, we see that the steel is the most costliest component. So, obviously, whatever the frames we are having they will remove it before demolishing the entire building. And as far as the steel which we used in the reinforced concrete, a different technique is applied because, let us say, if we have a concrete, let us say this is the concrete, and then there will be bonding between the steel and the concrete right. So, it is very difficult to remove it. So, initially, the demolition will be happening, and then we will be getting small size chunks right.

So, up to a length, the steel will be, you know, cut with the help of gas cutters or any other tools. But it will be very difficult to remove the steel, which is just inside the concrete chunk, because it is embedded in the concrete. The only way this steel can be removed is by reducing the size of the concrete chunk. So, here in this picture, you can see these people wanted to remove the steel. So, with the use of the hammers, they are demolishing the concrete.

But obviously, as you can see, it is very energy-intensive, and then you know it might not be cost-effective also. So, normally, the buildings are demolished, and the size of the concrete that we will be getting will be roughly around 400 mm to 1 metre, and then the steel which will be inside that it will be remain intact. So, the segregation can also happen, you know, at the recycling plants also. So, here you can see when the C&D waste is coming or the reinforced concrete is coming to the recycling plants the big size steel things and steel bars are removed. So, nowadays, if you see at the recycling plants, they are having the magnetic separators.

So, mostly two magnetic separators can be kept, one during the feeding side, where you are feeding the C&D waste, and one after the crushing unit. So, what happens when we are feeding? So, this is the magnetic separator, which is kept just after the feeding. So, the loose steel bars will be attracted by the these magnetic separators, and it will be able to separate it. And thereafter, the steel, which is inside the concrete chunks, So, after getting the crushed into small sizes, this magnetic separator will be able to remove these steel bars.

So, these are the photos that we have taken from South Africa. Here also, you can see big size magnets are kept before and after crushing, and they are able to attract the steel bars. So, apart from the steel, there will be different impurities. For example, plastic items, there will be paper, and then, at the plant itself, what happens when the material is fed? So, this is a magnetic separator which removes the steel bars, and after that, the C&D waste will be transferred from the feeding side to the crushing unit through the help of the conveyor belts.

So, here the labourers are standing, and they are picking the big impurities—wood, plastic, and aper. However, the issue happens with the small size portion, which are not being able to be removed by the labourers, or, you can say, cannot be removed manually. So, what happened in that scenario? The aggregates are crushed along with the impurities, and then for when the size is RC, let us say the size is fine RC that is less than 4.75 mm. Then the entire fine material will be submerged into the water, and then because these wood, plastic, and your paper are lighter than the aggregate,.

So, obviously, they will be floating, and then it will be easy to remove them from the C&D waste. So, here also, you can see a lot of plastic caps, and the smaller portion are removed

following this process. So, this is the process map of how the C&D waste are recycled in order to get recycled aggregates as well as recycled concrete aggregates. So, as we discuss, let us say this is a building. It is being demolished, and then the C&D waste is transferred to the primary collection area, where the initial sorting is happening. Subsequently, it will be sent to secondary crushing zone, where the from at this location the C&D waste is coming from different primary collection areas, and then it will be transferred to C&D plants. So, at the C&D plants also, this initial segregation will be happening, especially in the cases where the this note effective sorting has been done at the collection points, and thereafter, the only thing that will be remaining is resizing.

So, let us say we are getting the C&D waste chunks of size of around 400 to 500 m. So, it will be crushed. So, and then, after crushing, with the help of the sieves, it can be separated into different sizes based upon the requirement, for example, from 10 mm to 4.75 mm, 10 to 20, 20 to 14, 40 to 60. So, however, in the case where we have mixed excavated soil, for example, in the case of the mixed C&D waste, which can have a huge quantity of the excavated soil, after crushing there will be wet process that will be applied.

So, in case of the wet process, what happens after separating out the coarse aggregate? The fine aggregate, which is lesser than 4.75 mm, will be submerged into the water, and then, by following this wet process method, the sand could be could be you know separated from the silt, the clay particles, or, we can say, the soil particles. So, in this picture, you can see this is the excavated soil from the mixed C&D waste.