Hydration, Porosity and Strength of Cementitious Materials

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Lecture - 06
Aggregates

Hi, Good morning to one and all, I am K V Harish, assistance professor, Department of Civil Engineering, IIT Kanpur; you are watching MOOCs lecture course on hydration porosity and strength of cementitious material.

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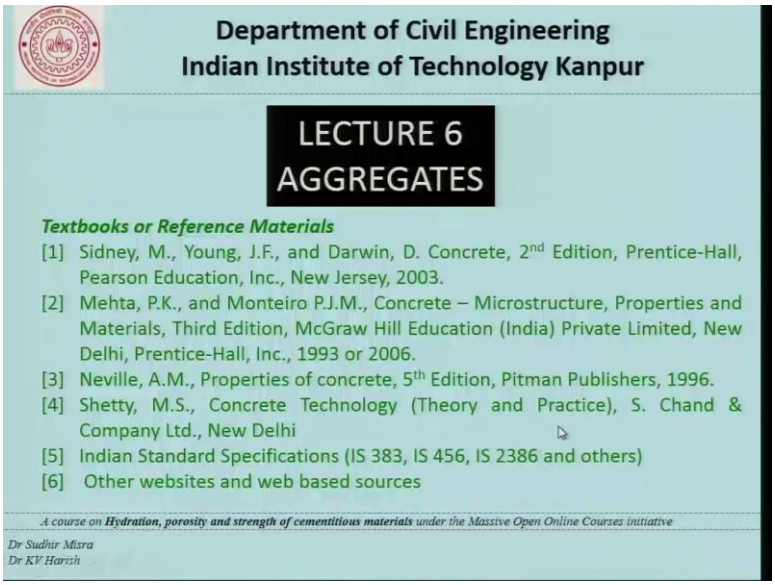

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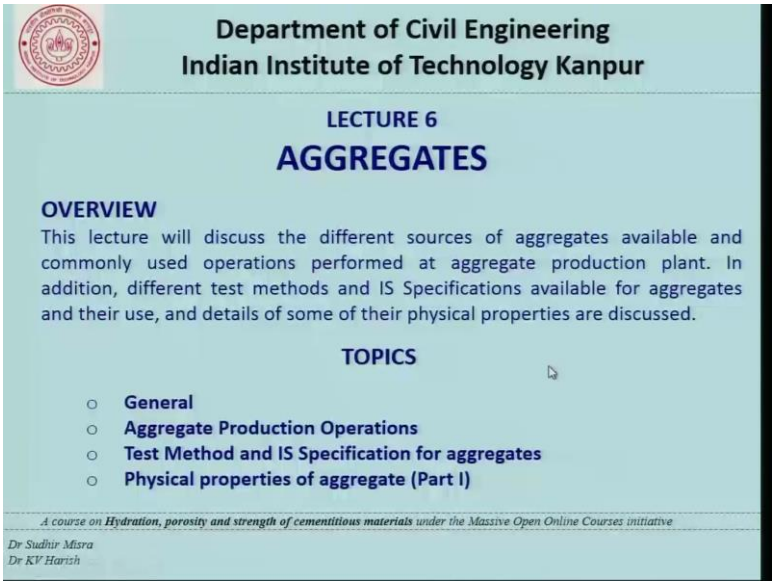

The text book and reference material are shown here today we will see lecture 6 aggregates overview, this lecture will discuss the different sources of aggregates available and commonly used operations performed at aggregate production plant in addition different test methods and IS specification available for aggregates. And there use and details of some of their physical properties are discussed topics involve general information aggregate production operations test method and IS specification for aggregates and overview and physical properties of aggregates part 1.

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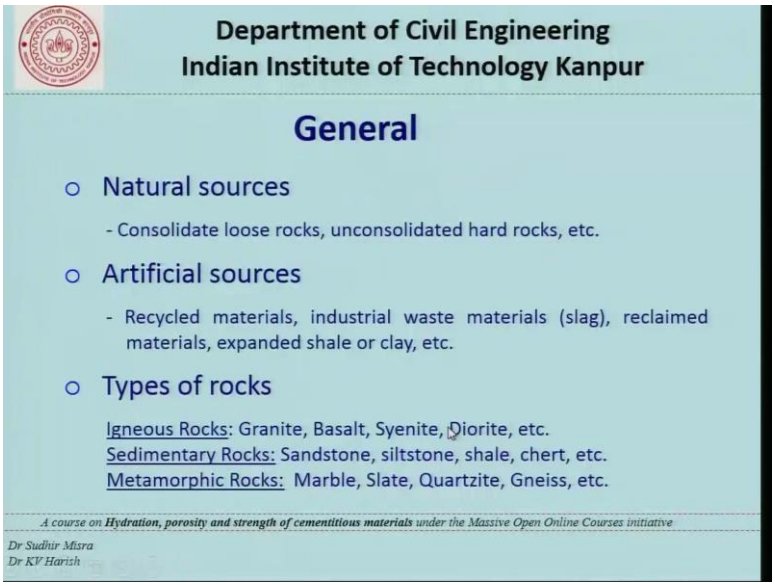

Aggregates are available from both natural and artificial sources natural sources such as consolidate loose rocks unconsolidated hard rocks, etcetera artificial sources like recycled materials industrial waste materials such as slag which can be used make artificial aggregates reclaimed materials expanded shale or clay etcetera, the type of rocks from which we get natural aggregate include igneous rocks sedimentary rocks and metamorphic rocks and igneous rocks famous example or granite, basalt, syenite, diorite, etcetera and examples of sedimentary rocks are sandstone, siltstone, shale, chert, etcetera, metamorphic rocks example marble, slate, quartzite, gneiss, etcetera.

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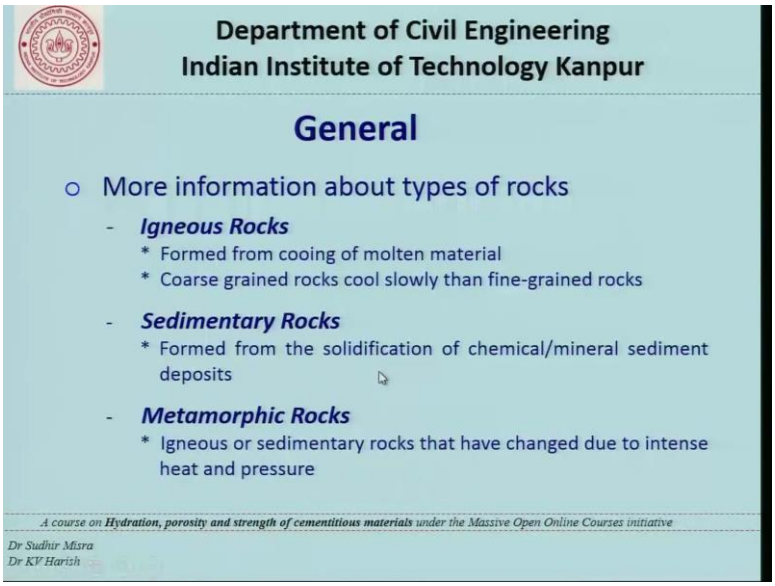

More information about types of rocks igneous rocks there usually formed from cooling of molten material there are differences between coarse grained rocks and fine grained rocks within igneous rocks coarse gained rocks cool slowly then fine gained rocks and because of that the physical and chemical properties may be different sedimentary rocks there are formed from the solidification of chemical or mineral sediment deposits metamorphic rocks which are originally igneous or sedimentary rocks.

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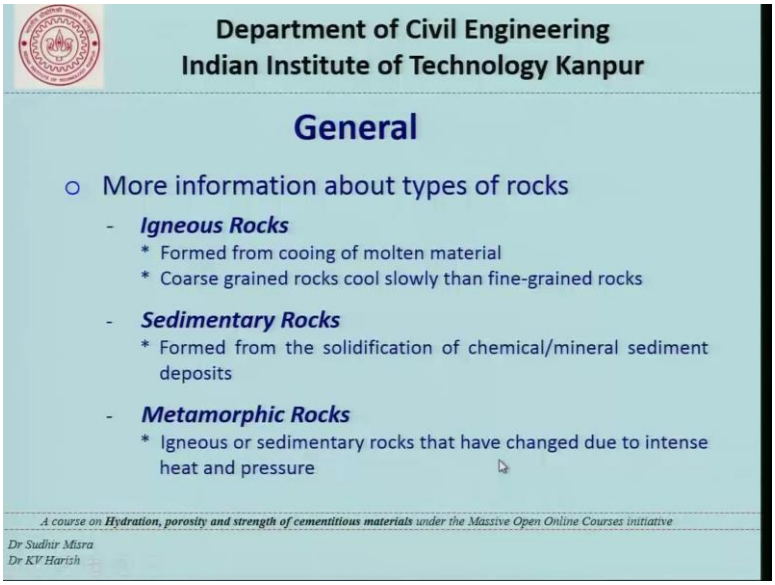

And that would have under gone some intense heat and pressure changes.

Now, aggregates are used for many civil engineering and construction applications some of them are listed Portland cement concrete masonry asphalt concrete base material for roads ballast for railroads foundations and other miner applications such as plastering mortar grout filter materials etcetera aggregates are extracted from rocks in quarries using different operations.

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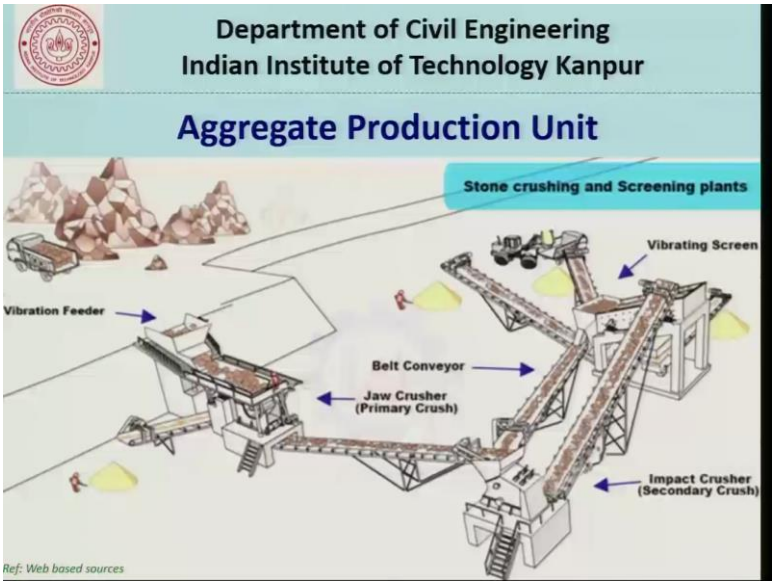

So, in the figure what you see is a aggregate production unit in one side, you have the natural resources available in the form of rocks and in the other side you have the aggregate production unit which is usually install very close to the aggregate source. So, the aggregate production unit consist of vibration feeder primary crusher secondary crusher some belt conveyors vibrating screens and also you have some stock files and we will see each one of them in detail.

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So, aggregate production operations include the following extraction or mining crushing or grinding screening or sizing handling and transporting washing dusting and drying stockpiling or storage in extraction or mining usually blasting stripping drilling or dredging operations or perform.

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Now, the figure here shows the blasting operations drilling operation stripping operations and dredging operation as you can see that depending upon the hardness of rocks each of these operations or carried out if the rocks are hard a nature then blasting and drilling operation may be require if the source of rocks or softer in that case here you have soft material stripping is used if the aggregate sources or delay water bodies in that case the process of dredging is used.

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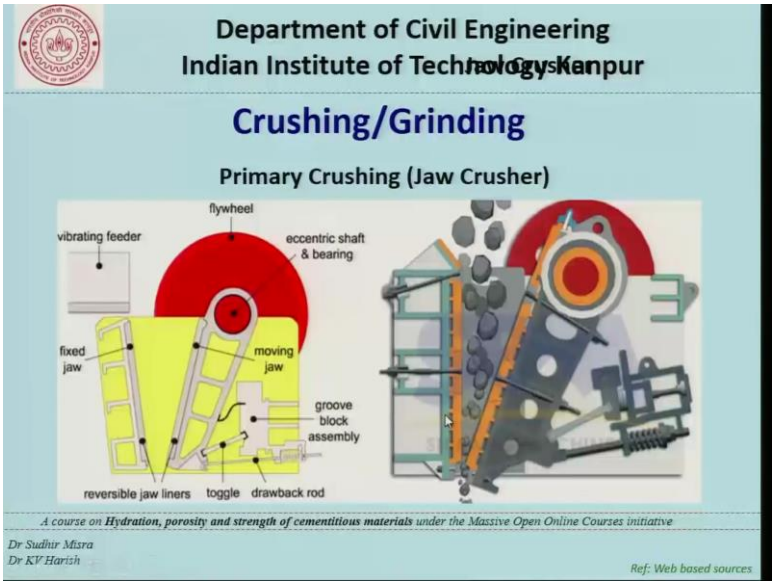

Now, the second one is crushing or grinding and in that what we see is that we have something called as primary crusher and the jaw crusher or very often use for primary crushing and here you have two figures to the left you have the figure without aggregate feeder it. So, the primary crush essentially consists of a fixed jaw more or less vertical and you also have a moving jaw which is inclined some angle. So, that the spacing at the bottom is lower compare to the spacing at the top.

So, that the aggregate can be feed from the top and collected at the bottom now the moving jaw basically vibrates using some mechanism here and once the aggregate or feeden the movement of the jaw basically breaks the aggregated into finer particles and finally, the finer particles comes out of the bottom.

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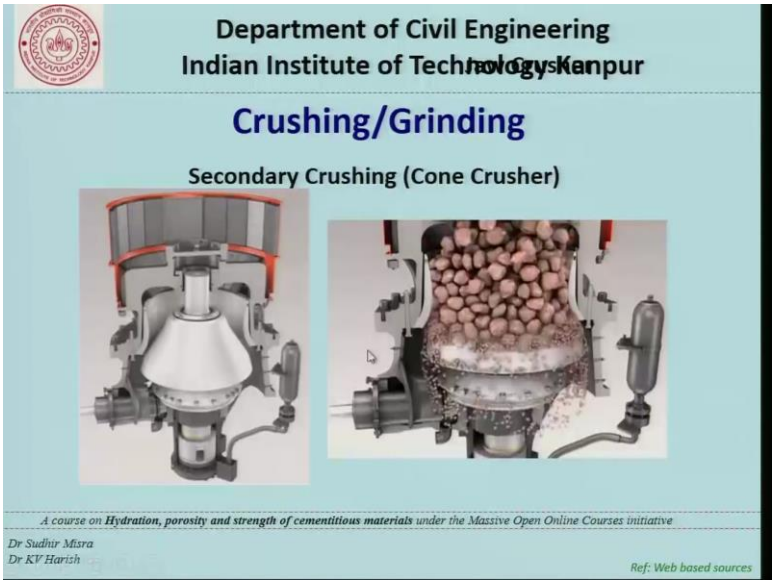

In the second case, we have secondary crusher one example of secondary crusher is cone crusher where you have a cone that is rotating at some angle this part receives the aggregate and the rotation of the cone basically crushes the aggregated into finer parts. So, in this figure what you see is the coarse aggregate that are feed from the top and because of the revolution of the cone.

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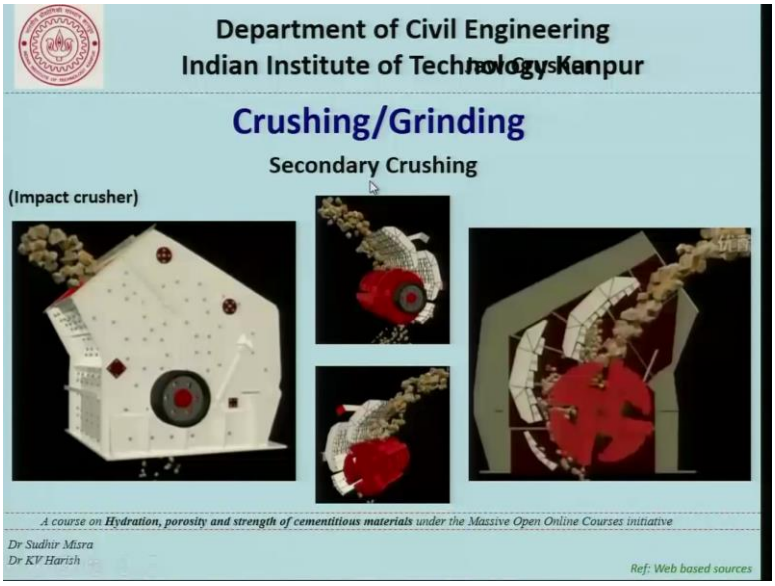

The spacing on the outer side in the cone to the equipment is very small and because of that the aggregates get crush and the finer aggregates are collect at the bottom the other secondary crusher is called as impact crusher where the aggregates or feeden from the top and you see that you have a revolving shafts inside the equipment there are totally three blades which are at some distance from the rotating shafts. And once the aggregate feed in because of the revolution of the shafts the aggregate or tangentially heat in some direction and because the plates are provided at some angle. The aggregates get impacted on the blades and broken down into smaller particulars and further because of the rotation of the shafts the finer particles again or tangentially heat on the next blade that is available and like vice the third blade and finally, the finer particles comes down.

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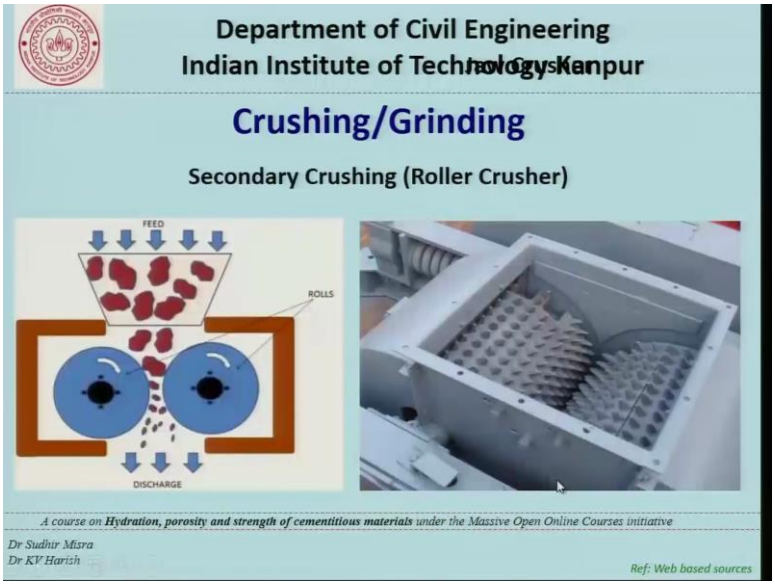

You also have another type of secondary crushing unit called as roller crusher in which two rollers or fixed at some distance and the aggregate or feed from the top; obviously, the spacing this much higher at the top and because of the roller the aggregate materials or broken down into finer particles this is the typical figure of a roller crusher.

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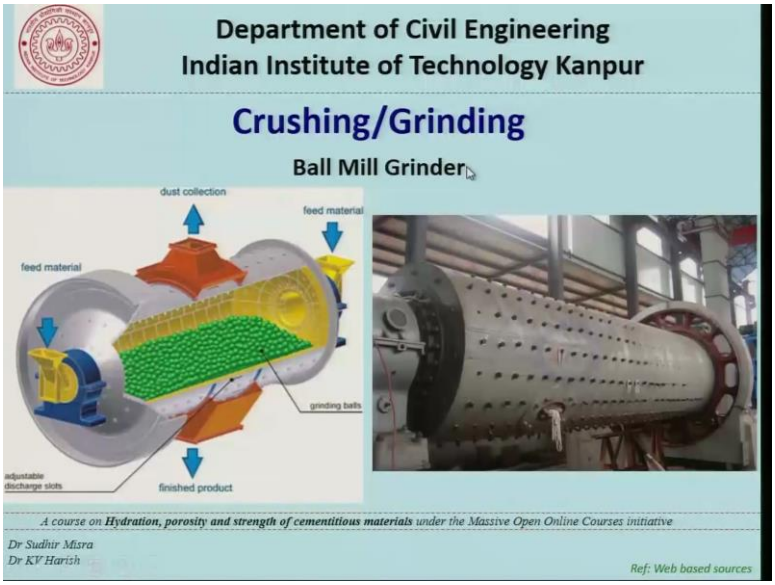

In addition to the primary and secondary crushing sometimes ball mill grinders are also used, but remember that ball mill grinders are primarily used to make the particle size to

small these are usually used in cement plants the schematic sketch and the real picture is shown here.

So, basically the ball mill grinder consist of a cylindrical shape drum and you have usually steel balls or many time referred as external charge the materials that has to be crushed or feeden and this entire cylindrical cell is closed and the cylindrical cell is resolved so that the impact of the external charge is felt on the material that as feeden and because of abrasion and attrition the feed material is broken down to smaller particles.

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So, in this figure, what we see is a crushing screening and conveying unit all club together. So, all that you can see is that bigger rocks or feed here and they are basically broken down in a primary crusher unit and it is taken over by some conveyer bills and some screen are available to divided into a specified particles size and finally, you see that they are stored in stockpiles.

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In addition to these you also have handling and transporting equipments like conveyors bills conveyors. So, here you can see that the material or feed from one location in the plant to another location in the other case one location to dram truck and like vice you also have telescopic conveyors which can actually increasing in length if the distance to convey the material is more.

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In addition to this you also have dram trucks which unload and load materials and in addition to that you also have tower cranes which can transport or convey materials from one location to another within the site.

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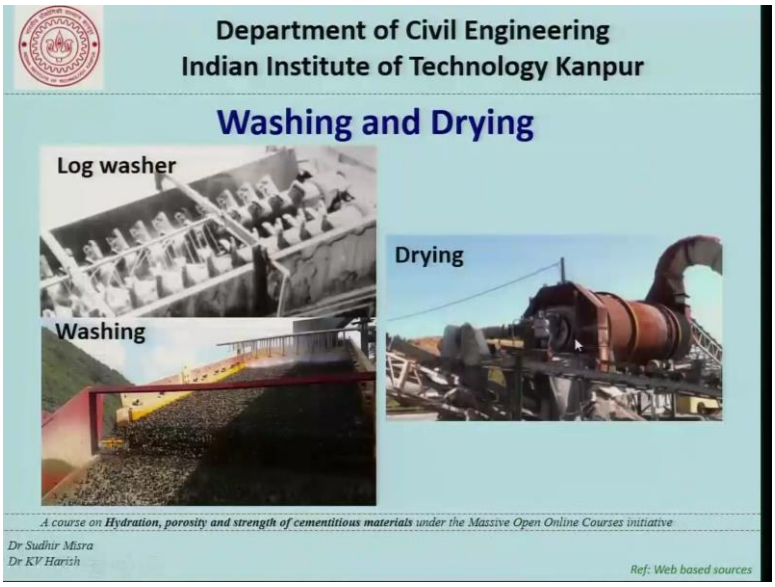

So, next operation is washing and drying usually in this process whenever the aggregate is passing from one location to another spring clay systems are usually install through which water is feed into it and the dust material and the others are removed by constant sprinkling of water. So, log washer is shown and washer unit which is installed in a conveyer belt is also shown in the other figure what we see is a drying unit more like a cylindrical unit which convey dry air to the aggregates this type of drying unit is not very common for aggregates use in concrete where as this is very very common for when aggregates are use for bituminous or asphalt concrete applications.

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So, once you get the aggregates of different sizes they are actually kept in stockpiles and later on dram trucks come to the aggregate production plant and take it to the site where the construction is performed. So, in this figure you see the coarse aggregate piles and in the other figure you see the fine aggregate piles.

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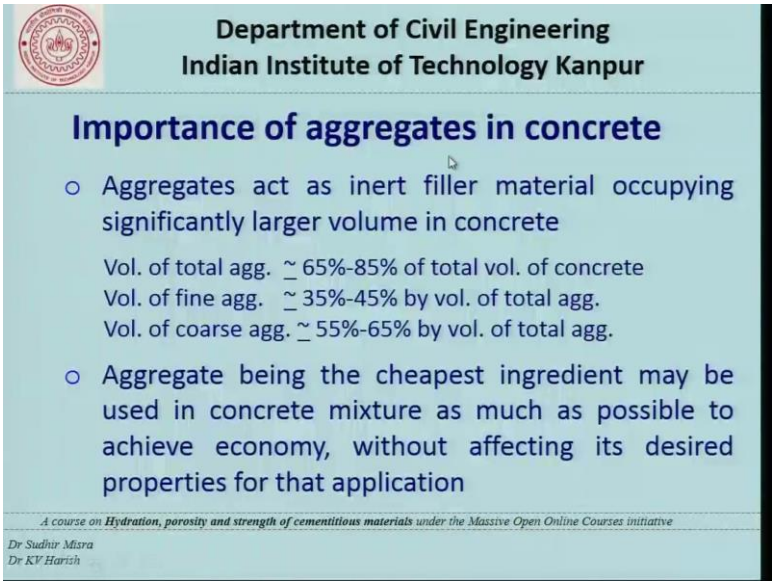

Now, what is the important of aggregates in concrete aggregate act as inert filler material occupying significantly larger volume in concrete volume of total aggregate is approximately 65 to 85 percentage of the total volume of concrete volume of fine

aggregate alone is approximately 35 to 45 percentage by volume of total aggregate and like vice volume of coarse aggregate is approximately 55 percent to 65 percent by volume of total aggregate being the cheapest ingredient may be used in concrete mixtures as much as possible to achieve economy without affecting its desired properties for that particular application.

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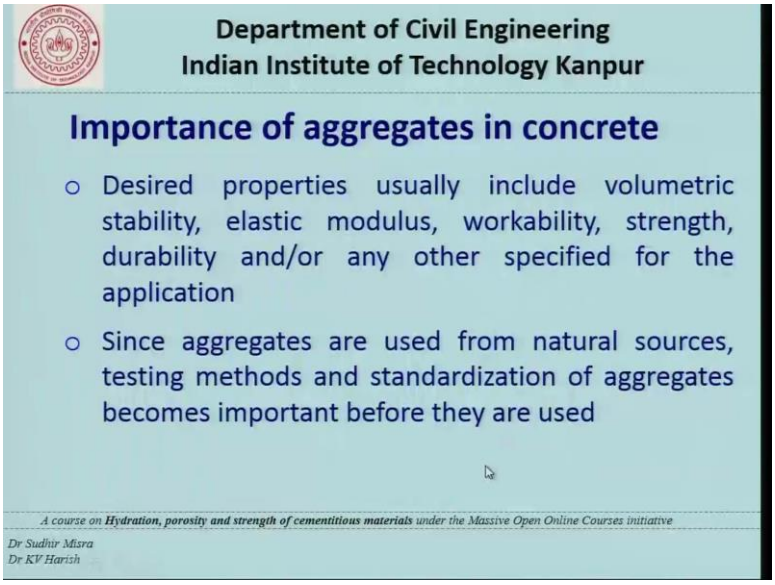

Desired properties usually include volumetric stability elastic modules workability strength durability and any other specified property for that application since aggregates are used from natural sources test methods and standardization of aggregates becomes important before they are used for any application.

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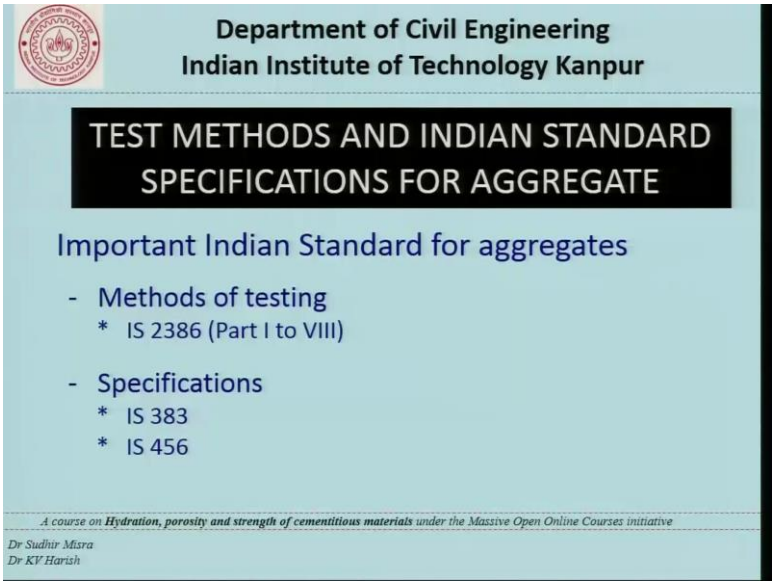

So, Indian standard specification for aggregate are as follows we have IS 2386, part 1 to part 8 which covers the methods of testing and IS 383 and IS 456 which are specification.

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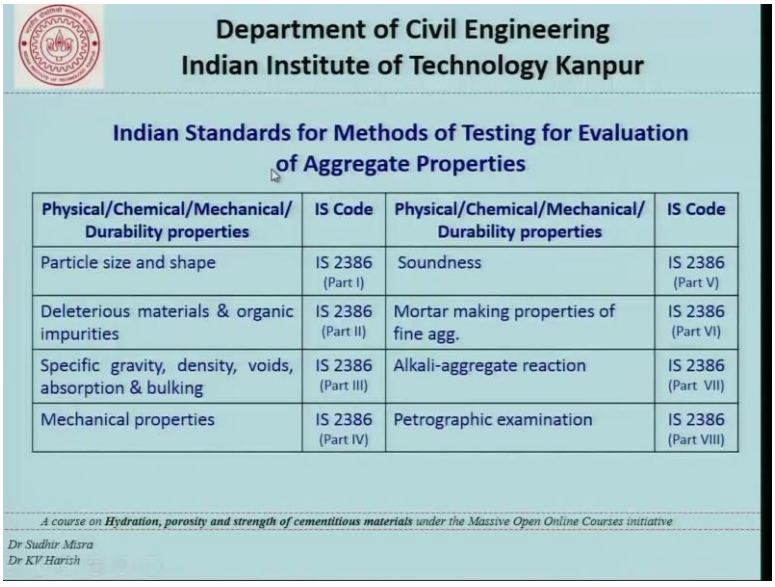

Physical/Chemical/Mechanical/ Durability properties	IS Code	Physical/Chemical/Mechanical/ Durability properties	IS Code
Particle size and shape	IS 2386 (Part I)	Soundness	IS 2386 (Part V)
Deleterious materials & organic impurities	IS 2386 (Part II)	Mortar making properties of fine agg.	IS 2386 (Part VI)
Specific gravity, density, voids, absorption & bulking	IS 2386 (Part III)	Alkali-aggregate reaction	IS 2386 (Part VII)
Mechanical properties	IS 2386 (Part IV)	Petrographic examination	IS 2386 (Part VIII)

So, IS 2386 provides the following test as you can see that you have particle size and shape deleterious materials and organic impurities specific gravity density voids absorption and bulking mechanical properties soundness mortar making properties of

fine aggregate alkali aggregate reaction petrographic examination and these are covered in part 1 through part 8.

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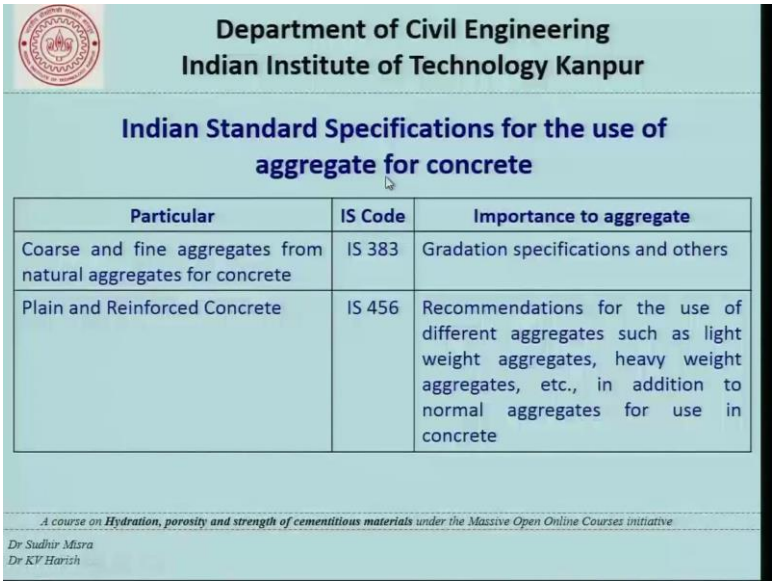

In the case of IS 383 specification which is for coarse and fine aggregate from natural aggregates for concrete the importance is that it provides the gradation of fine aggregates and coarse aggregate that we can use for different applications IS 456 is primarily for plain and reinforced concrete and the these are recommendation for the use of different aggregates such as light weight aggregates heavy weight aggregates etcetera in addition to the normal aggregates that we get from natural resources for use in concrete.

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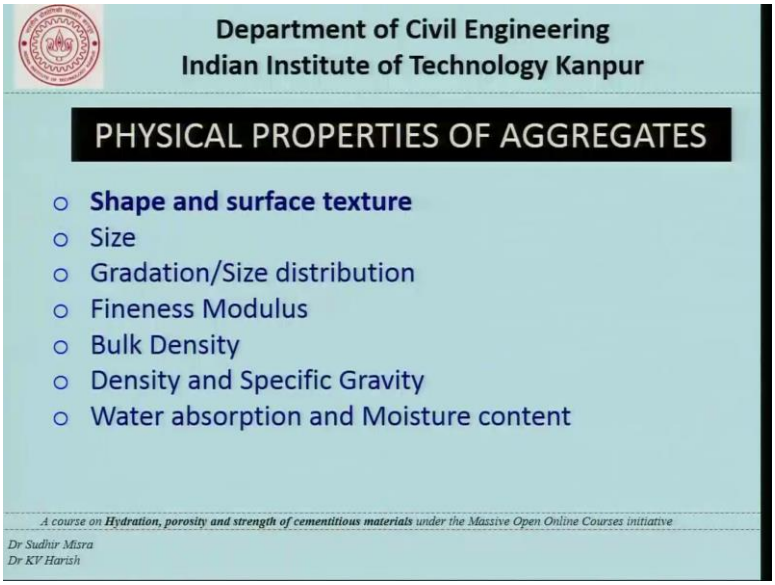

So, the physical properties of aggregates plays a very important role now the different physical properties of aggregates include shape and surface texture size gradation or size distribution fineness modulus bulk density, density and specific gravity water absorption and moisture content in this lecture we will see only about shape and surface texture in other lectures we will see the remaining part.

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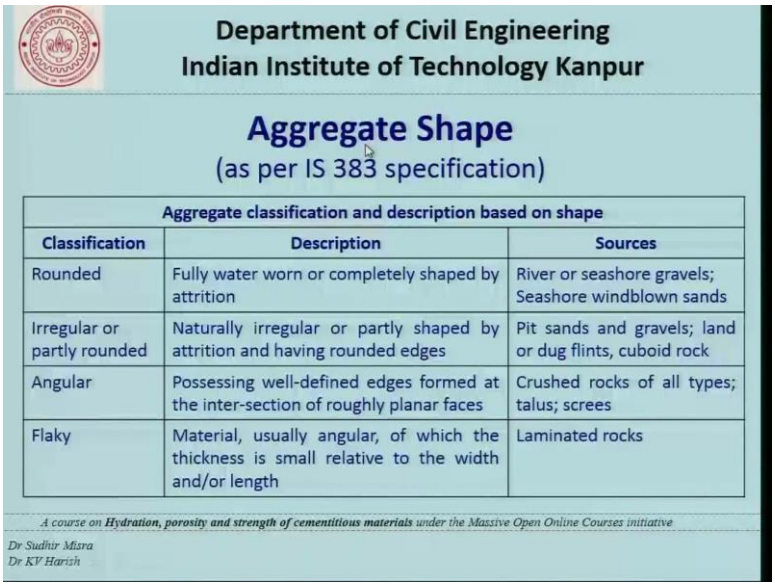

Now, aggregate shape the aggregate shape is specified in IS 383 specification as follows rounded shape irregular or partly rounded angular and flaky and the description that is

given for rounded is fully water worn or completely shaped attrition for irregular or partly rounded the description is naturally irregular or partly shaped by attrition and having rounded edges for angular.

It is processing well defined edges formed at the inter section of roughly planar faces for flaky material usually angular of which the thickness is small relative to the width and or length and the sources for these aggregates or provided here to understand the shape and surface texture, we need some more explanations.

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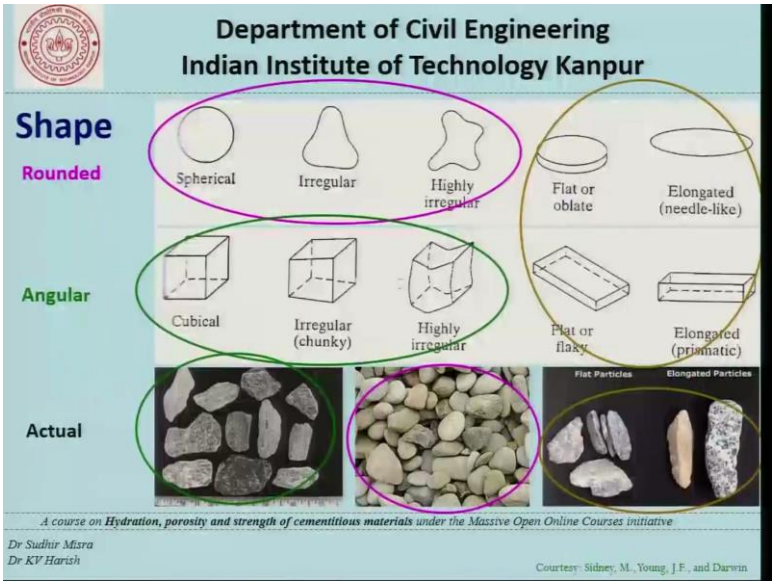

So, in this slide what we see is that we have three categories one is rounded the other one is angular and the other one is flat or elongated in the rounded I show in the pink circle the shapes the perfectly curved or spherical shapes are shown in the first it is spherical the other one is its curved, but irregular the other one it is highly irregular and curved in a case of angular again there are three figure shown one is cubical perfectly uniform cubical aggregate are shown. Then you have irregular shapes then you have highly irregular shapes like vice in flat and elongated you have perfectly flat or oblate perfectly elongated or needle like perfectly flat or flaky perfectly elongated or prismatic and what we have to understand is that since aggregates or taken from natural sources and you have different operations involved during its extraction we see that the aggregates are not perfectly rounded not perfectly angular or not perfectly flat or elongated.

So, the actual shapes that we have is shown here for a angular aggregate typically the shape is like this for a rounded or spherical aggregates the shape is somewhat like this and for a flat or elongated aggregates the shape will be somewhat like this; this will give some understanding about the actual shapes and surface texture of aggregates.

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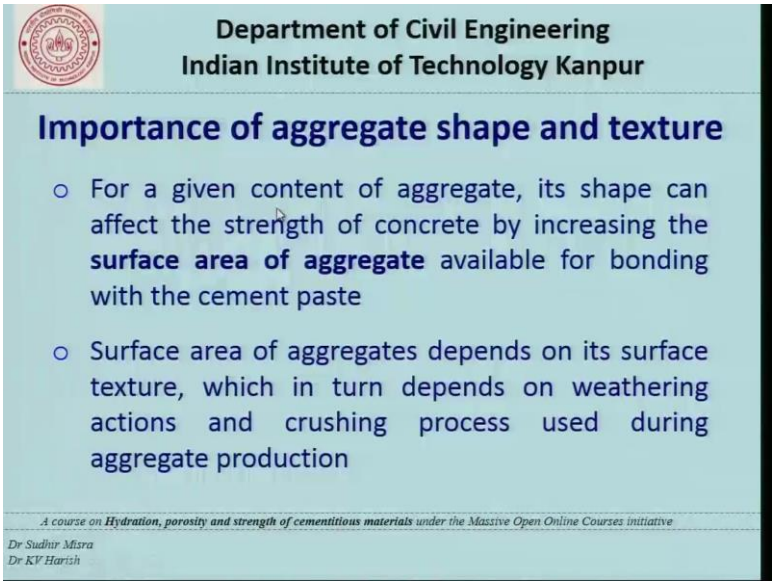

So, what is the importance of aggregate shape and surface texture for a given content of aggregate its shape can affect the strength of concrete by increasing the surface area of aggregate available for bonding with the cement paste surface area of aggregates depends on its surface texture which in turn depends on weathering action and crushing process used during aggregate production aggregate shape and texture can affect the following properties of concrete it can affect the paste content otherwise called as paste requirement for fixed workability or strength of concrete it can affect the workability or strength of concrete for fixed paste content for this purpose the performance of rounded aggregates and angular aggregates or uniform aggregates and non uniform aggregates or many time compare.

So, it is importance for us to know what are advantages of rounded aggregates angular aggregates and what are the disadvantages of flat or elongated aggregates.

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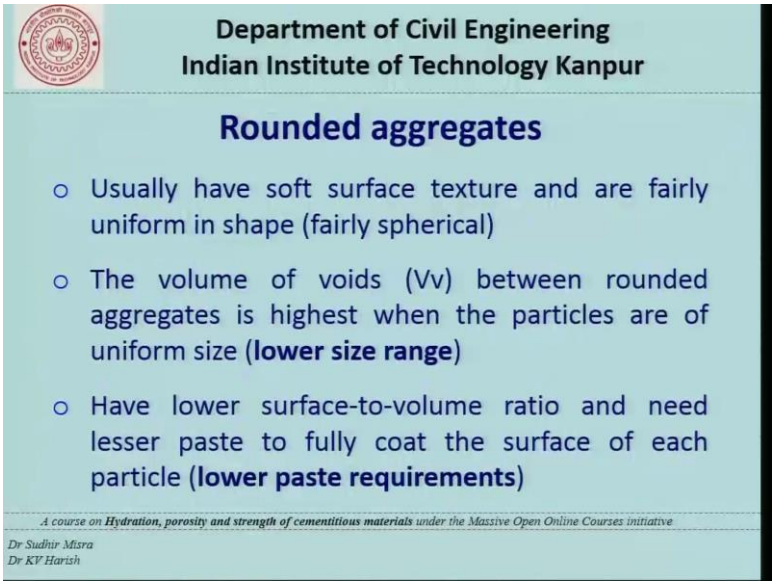

Now, rounded aggregates you rounded aggregate usually have soft surface texture under fairly uniform in shape. So, they are explain many time as fairly spherical the volume of voids Vv between rounded aggregate is highest when the particles are of uniform size; that means, in the particle have lower size range the volume of voids is higher rounded aggregates also have lower surface to volume ratio and they need lesser paste ratio to fully coat the surface of each particle this is many times explained as lower paste requirements.

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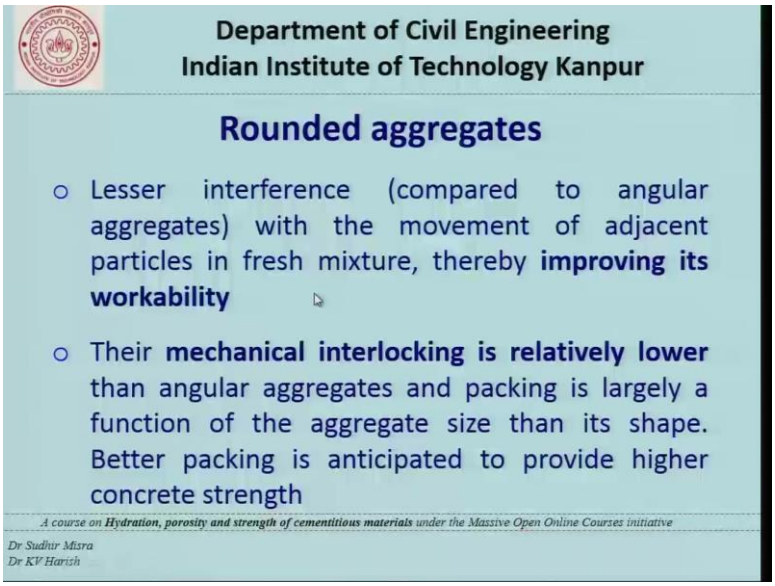

In addition rounded aggregates have lesser interference compare to angular aggregates with the movement of adjacent particles in fresh mixture thereby improving its workability. So, from workability stand point rounded aggregates or largely preferred their mechanical interlocking is relatively lower than angular aggregates and packing is largely a function of the aggregates size than its shape better packing is anticipated to provide higher concrete strength.

So, one of the disadvantage of rounded aggregates is that the mechanical interlocking is relatively poor and hence we have to make sure that when we are using rounded aggregates we use a well guided aggregate so that we can achieve better packing.

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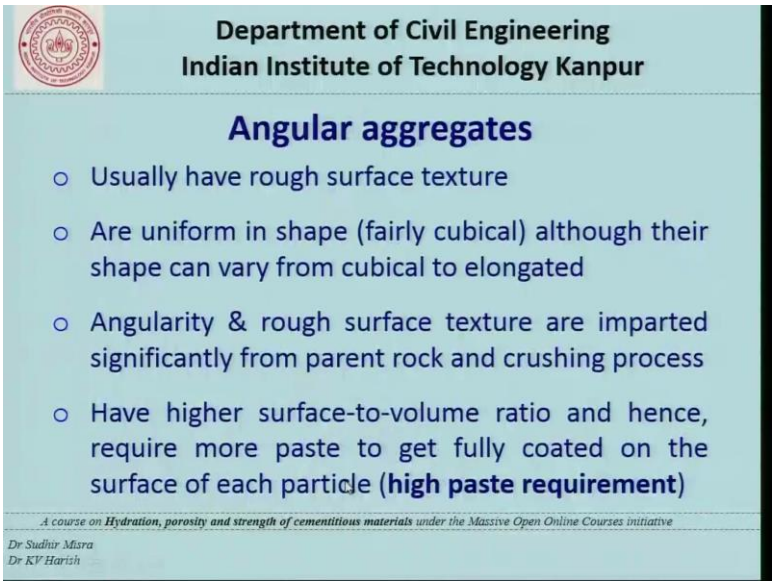

Now, importance of angular aggregates angular aggregates usually have rough surface texture they are uniform in shape explained as fairly cubical although their shape can vary from cubical to elongated angularity and rough surface texture are imparted significantly from parent rock and crushing process angular aggregates have higher surface to volume ratio and hence the require more paste to get fully coated on the surface of each particle and this is one of the reasons where paste requirements or higher for angular aggregates.

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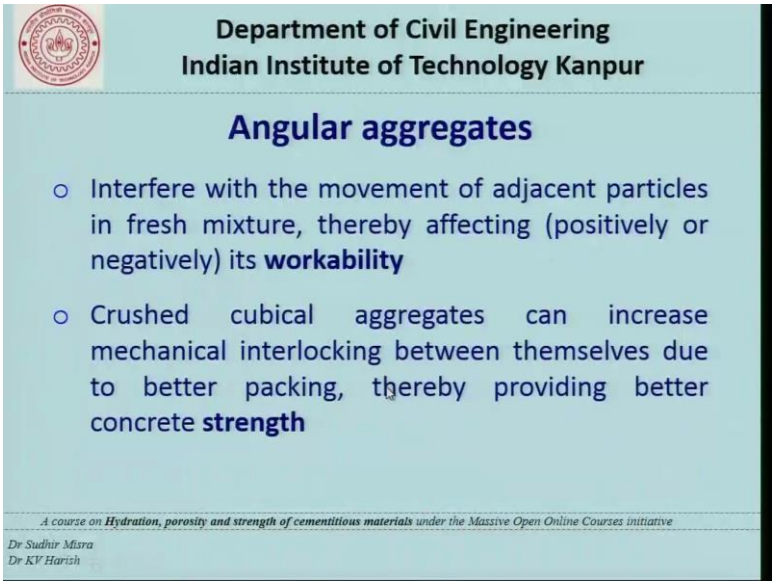

In addition angular aggregates interfere with the movement of adjacent particles in fresh mixture thereby affecting its workability remember workability can be positively affected or negatively affected and that again depends on several other factors crushed cubical aggregates can increase mechanical interlocking between themselves due to better packing thereby providing better concrete strength.

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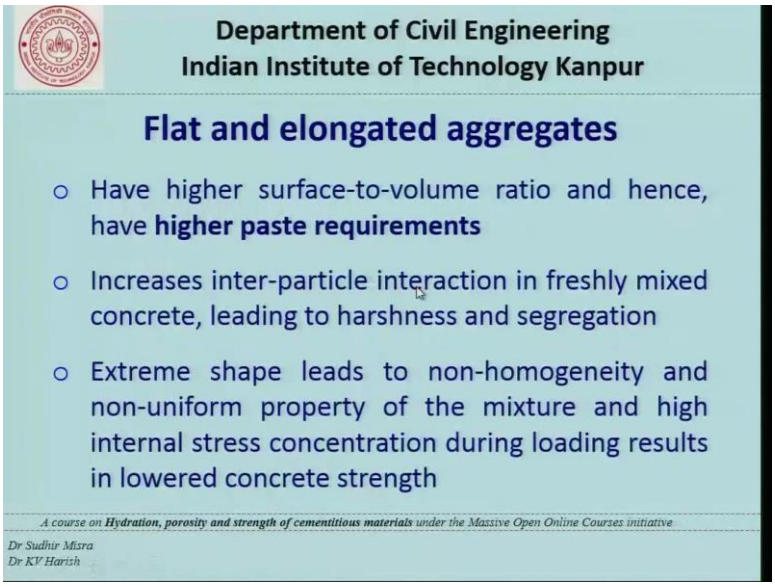

So, from the stand point of packing and from the stand point of strength angular aggregates or generally preferred compare to other aggregates now flat and elongated

aggregates flat and elongated aggregates have higher surface to volume ratio and hence have higher paste requirements. They increase the inter particle interaction in freshly mixed concrete leading to harshness and segregation flat and elongated aggregates leads to non homogeneity and non uniform property of the mixture and high internal stress concentration during loading which results in lowered concrete strength. So, from the stand point of strength flat and elongated aggregates are not used it is the come to an end for this lecture.

Thank you.