**Ocean Structures and Materials**
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**Module - 2**
**Lecture - 4**
**Dredging I**

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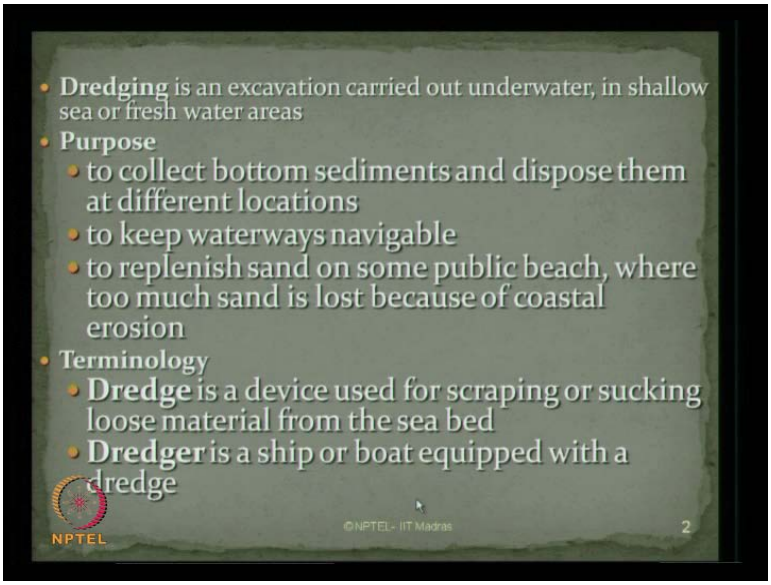


The NPTEL is a course run by IIT-Madras. In this lecture we will talk about some aspects of dredging. Fundamentally, the question is what do you understand by dredging? Dredging is an excavation carried out underwater, in shallow sea or fresh water areas.

What are the purposes for dredging to be done? It is essentially done to collect bottom sediments and dispose them at different locations- to keep waterways navigable and also to replenish sand on (( )) some public beach, where too much sand is lost because of coastal erosion.

There are some terminology used commonly in dredging, let us see them one by one. What do you understand by a dredge? Dredge is a device used for scraping or sucking the loose material from the sea bed. Dredger is a ship or vessel, which is equipped with a dredge.

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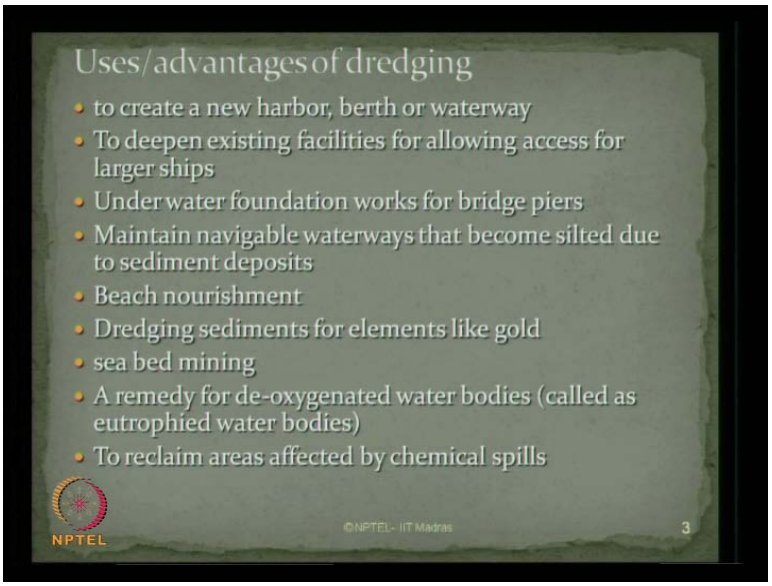


What are the advantages of doing dredging? Essentially, if you want to create a new harbor, berth or waterway, dredging is to be done mandatory. To deepen the existing facilities for allowing access for larger ships, which requires deeper draft; underwater foundation works for bridge piers requires dredging to be carried out. To maintain navigable waterways, that become silted due to sediment deposits in due course of time, and of course people do dredging for beach nourishment, dredging sediments for elements like gold.

Sea bed mining is also an important part where dredging is being done. It is also considered as important remedy for deoxygenated water bodies, which is otherwise called as eutrophied water bodies. To reclaim areas, which are affected by chemical spills dredging are usually done.

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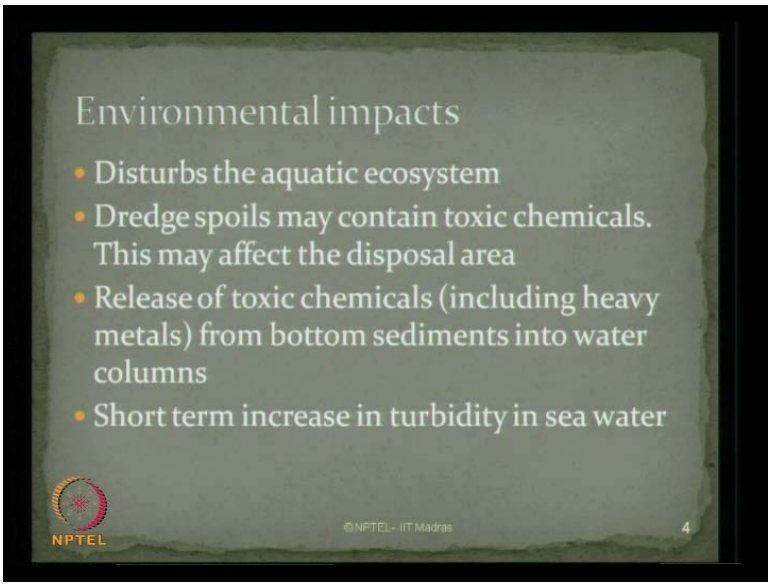


Let us see some environmental impacts, which are cast because of dredge. It disturbs the aquatic ecosystem. The dredge spoils, which are the loosened material collected from the sea bed may contain toxic chemicals, this may affect the ecological system of the area where they are disposed. The release of toxic chemicals, including heavy metals from the bottom sediments into water columns can also improve turbidity, which we call as short term increase in turbidity in sea water.

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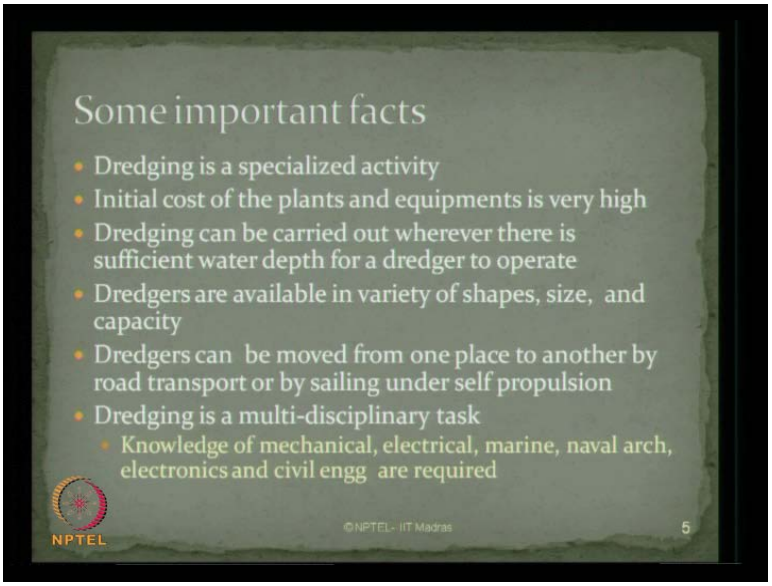


There are some important facts, which are associated with dredging, let us see them.

Dredging is, of course, is specialized activity. Initial cost of the plants and equipments involved in dredging process are phenomenally high. Dredging can be carried out wherever there is sufficient water depth for a dredger to operate. Dredgers are available in variety of shapes, size and capacity, which we will see one by one in this lecture.

Dredgers can be moved or transported from one place to another by road transport or sometimes, they are also equipped with self-propulsion systems by which they can be sailed off from one location to another location. Dredging is, of course multi-disciplinary task, ladies and gentleman. It requires knowledge of mechanical, electrical, marine, naval architecture, electronics and civil engineering together, applied for carrying it out a dredging operation.

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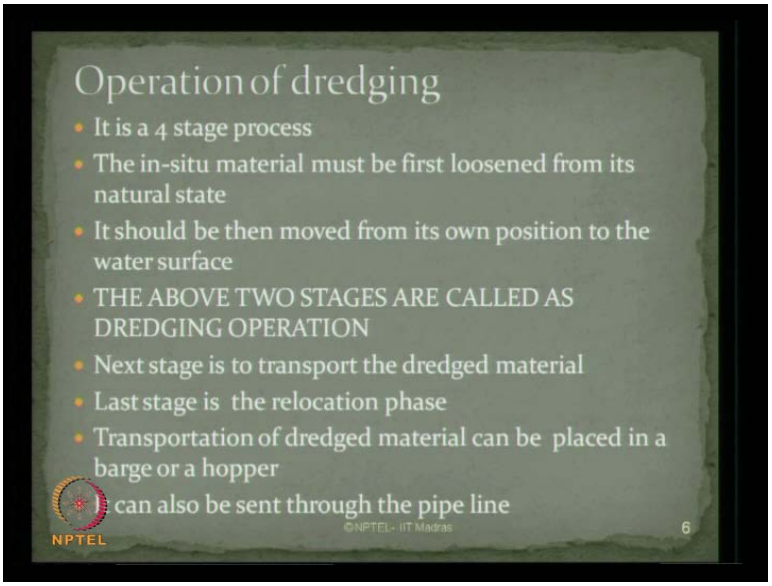


Operation of dredging is, essentially, a four stage process. In the first stage, the in-situ material, which is to be dredged, is loosened from its natural state. In the second stage, it is then moved from its own position of the deposits to the water surface. This process together, is called dredging operation.

Thirdly, in next stage, this collected material is to be transported. In the last stage, you have got to transport this, what we call as a relocation phase. Transportation of dredged material can be placed in a barge or in a hopper. It can also be sent, otherwise, through the pipe lines.

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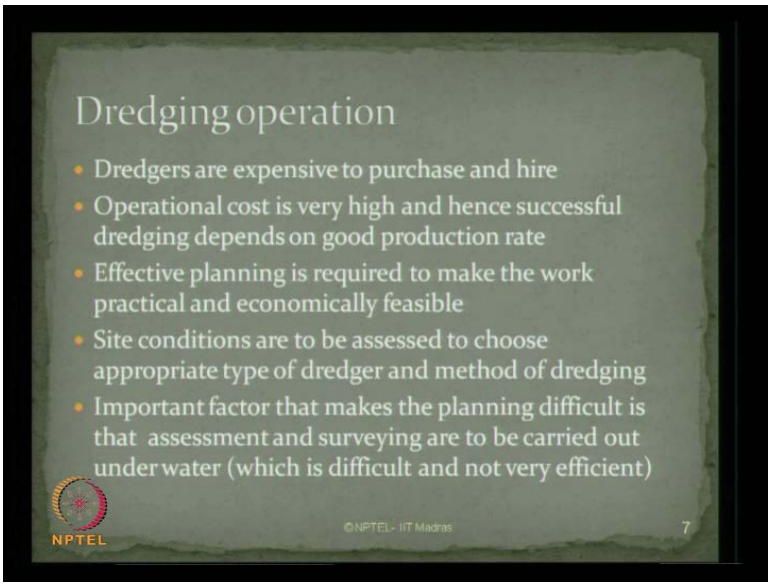


Dredging operations are expensive because dredges are very costly to purchase, as well as, to hire them. Operational cost is very high and hence, a successful dredging operation depends on a good production rate. Effective planning is, therefore, required to make the work practical and economically feasible. Site conditions are to be assessed to carefully to choose an appropriate type of dredger and of course, method of dredging, which can be deployed in the specific site. Important factor that makes the planning difficult is the assessment and surveying, which are to be carried out underwater to select a specific kind of equipped and plan that can be used for dredging.

Now, underwater survey, which are required to be done are very difficult. I do not have very efficient methods of doing these. Therefore, in the whole process of planning of dredging selection equipments, there can be a wrong selection of equipment or wrong method of dredging, which can decrease the rate of production. Therefore, the cost of dredging slowly and strongly depends on how you assess the requirement of type of plant and equipment that is required for dredging the specific material in that site.

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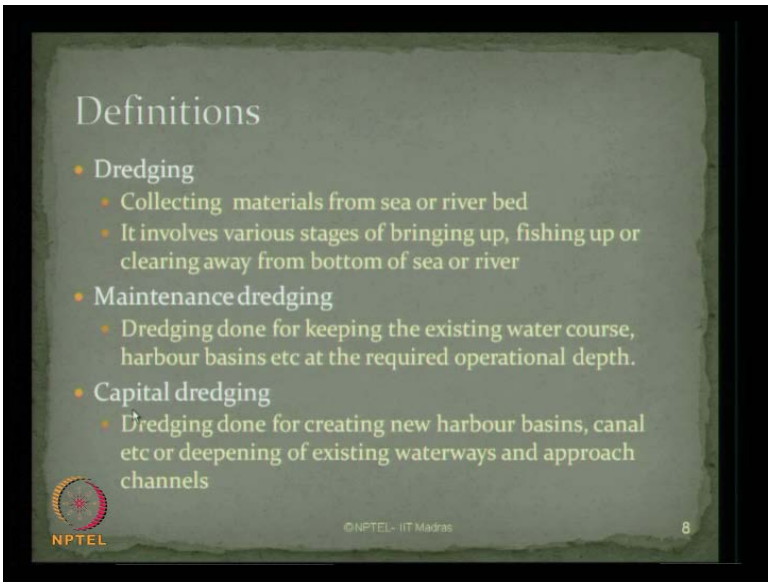


There are basic definitions, which are involved in dredging operations, let us see them one by one. Dredging, of course is defined as collection of material from sea or river bed. It involves various stages of bringing up, fishing up or clearing away from bottom of sea or river.

People do sometimes call maintenance dredging. When the dredging is done for keeping the existing water course, harbor basins, etcetera, at the required operational depth, then that kind of dredging is addressed in literature as maintenance dredging.

People also do sometimes call capital dredging. If dredging is done for creating a new harbor basin or a canal, etcetera, then or you can use in deepening of existing waterways and approach channels, we call this kind of dredging as capital dredging.

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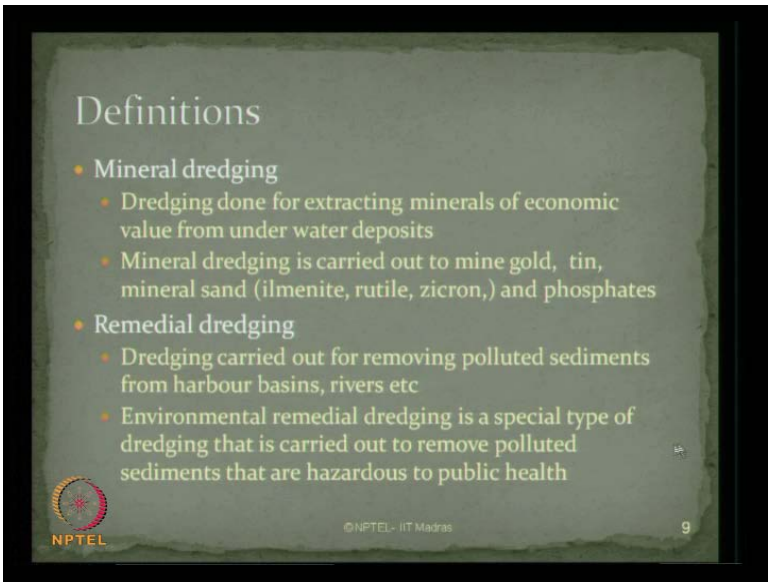


Sometimes, if we really do dredging for extracting minerals of economical value from underwater deposits, the mineral dredging carried out to mine gold, tin, mineral sands and phosphates. This kind of dredging essentially carried out for extracting minerals from underwater deposit is addressed as mineral dredging.

People also do remedial dredging. When dredging is carried out for removing polluted sediments from harbor basins, rivers, etcetera, then we called that as remedial dredging. Environmental remedial dredging is a special kind of dredging, which is carried out to remove polluted sediments that are hazardous to public health.

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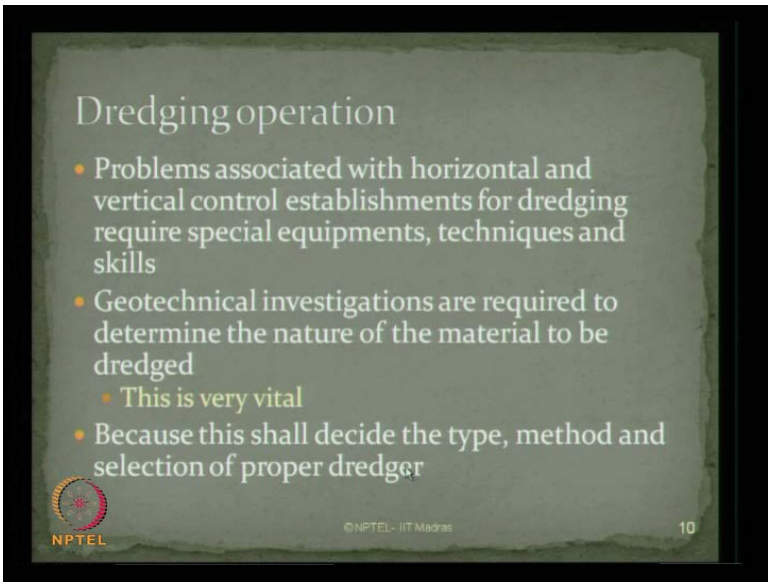


Let us quickly look at the complicity involved in dredging operation. There are different varieties of problems associated with dredging. The foremost problem is the horizontal and vertical control establishments. During the dredging operation, if really want to establish good control and a horizontal and vertical alignment of dredging that requires lot of special equipments, techniques and skills to be deployed.

Geotechnical investigations are required to determine the nature of the material that is to be dredged. This is very vital because this important, which can decide the type, the method and selection of a proper dredger for that kind of material, which is to be dredged.

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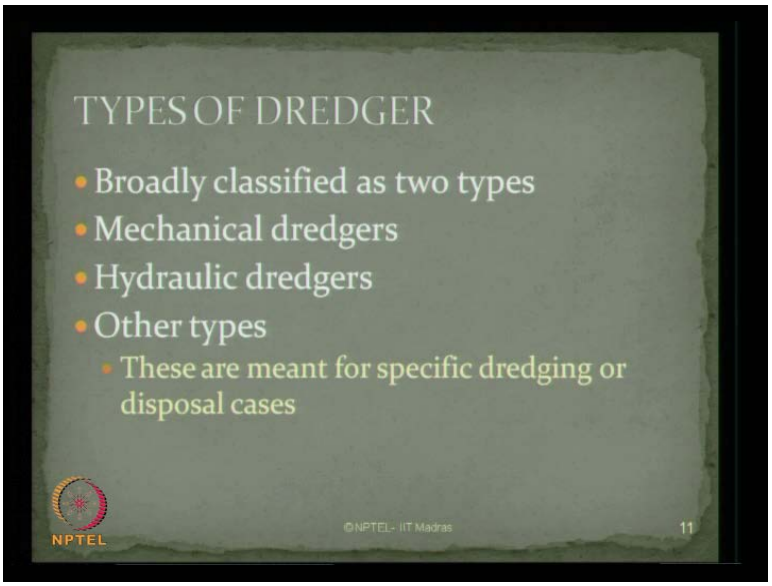


There are different types of dredgers; broadly, we can classify them into two types, mechanical dredgers and hydraulic dredgers. Unfortunately, all kinds of dredgers do not fall in these two categories. Therefore, the third, alike category is other types, because there are some specific kinds of, special kinds of dredging, which are carried out for disposable cases. Therefore, other types, does not qualify in either of mechanical or hydraulic dredgers. In this lecture we will see, one by one, different types with photograph and videos.

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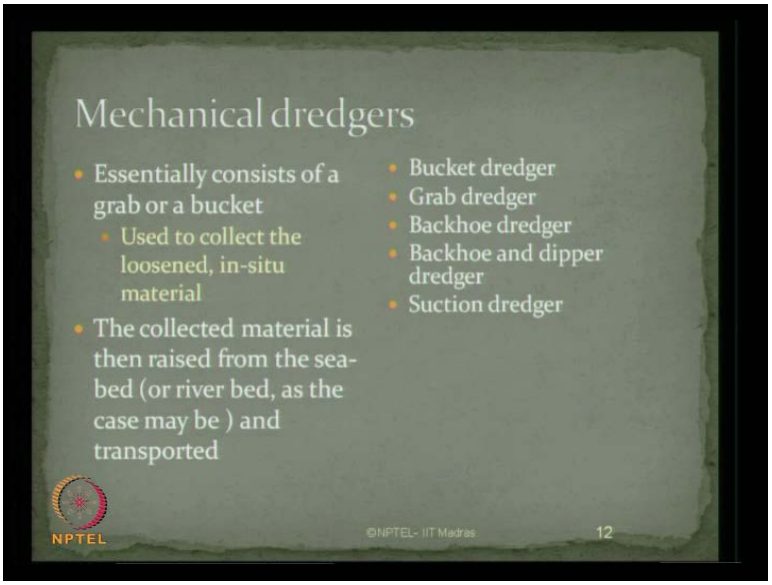

Let us quickly see what are mechanical dredgers are? Mechanical dredgers, essentially, consists of a grab or a bucket, which is used to collect the loosened in-situ material. The collected material is then raised from the sea-bed or it can be from the river bed, if you are using dredging for river and then the collected material should be transported. So, there are three stages of operation. One, employ the dredgers, and then collect the material, which is loosened from the sea-bed, then transport.

There are different types of mechanical dredgers available, as you see them on the slide. Now, bucket dredgers, grab dredger, backhoe dredger, backhoe and dipper dredger, suction dredger.

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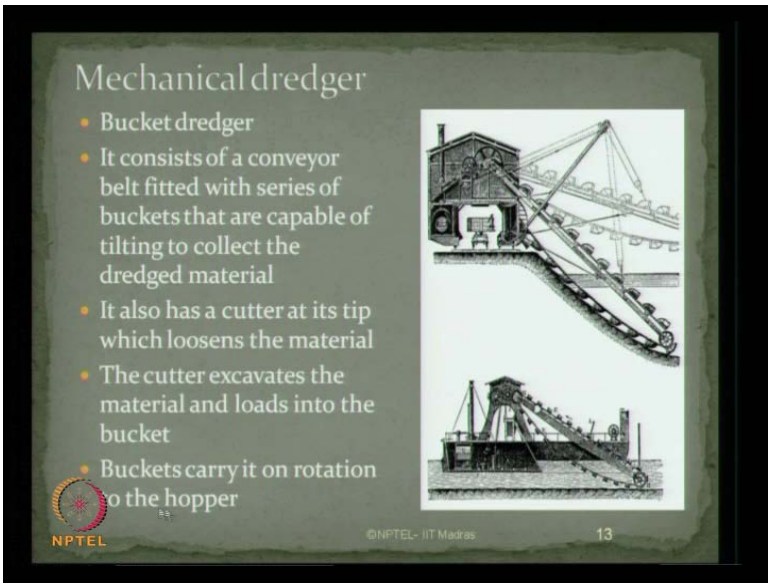


If you look at the first kind, which we called as bucket dredger, the photograph what you see here is a schematic view of bucket dredger. You can see, there is a series of conveyor belt, which houses different kinds of buckets, which are placed on this well. The tip of this conveyor has a scraper and the cutter, so this is helpful in loosening the material. As the bucket forwards to the zone where the cutting takes place, the bucket is loaded with loosened material and the bucket moves forward. As the belt move, buckets unloaded the collecting material in the hopper located here. So, tip of this is always equipped with cutter, which is helpful in loosening the hardened deposit buckets to collect the loosened material and transport it to the hopper from the hopper, which is collected so far. This can be further transported to a vessel or barge.

So, essentially, bucket dredger consists of a conveyor, which you see here with series of buckets that are capable of tilting to collect the dredged material. It also has a cutter at its tip, as you see here, which is helpful to loosen the material, which is hardened deposit in the sea-bed. The cutter excavates the material and loads it to the bucket, bucket carry it on rotation to the hopper.

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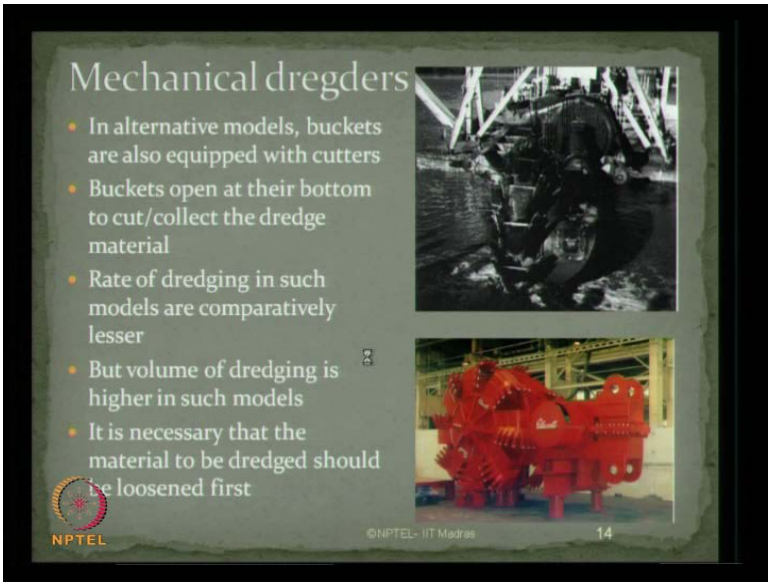


In alternate models, buckets are also equipped sometimes with cutters. The photograph, what you see here is bucket, which has got a cutter and a dredge. This is actually, typically, form of rotary cutter, which is used in form of the bucket to collect the sediments from the sea bottom. Buckets open at their bottom to collect or to cut the dredge material.

The rate of dredging in such kinds of models is comparatively lesser, but the volume of dredging in these models is phenomenally high. It is, therefore necessary, that the material to be dredged should be loosened first, because the cutter may not be efficient to create the loosened material at the sea-bed. Therefore, the material should be first loosened before the dredging is put into the operation.

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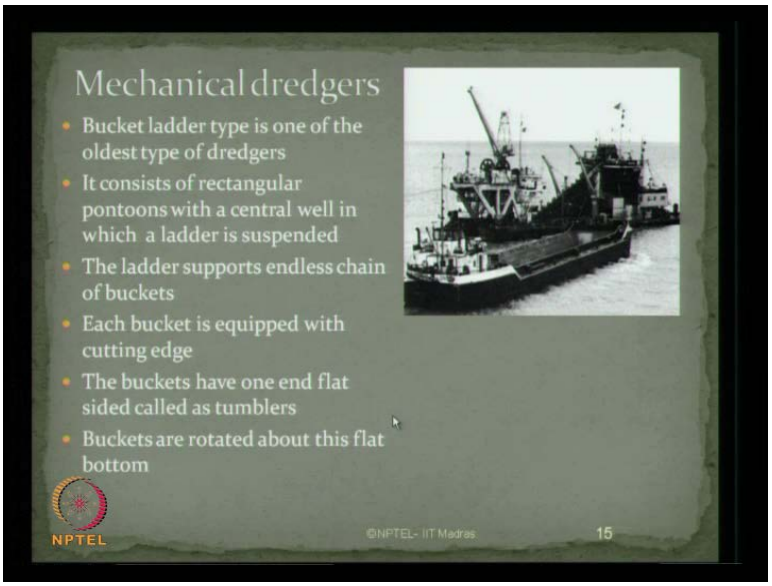


Bucket ladder type is another kind of dredger, is mechanical type, which is being used since olden days. There is a ladder, which houses a series of bucket here instead of conveyor belt. It essentially consists of rectangular pontoon type with a central well in which a ladder is suspended. The ladder supports endless chain of buckets; each bucket is, of course, equipped with cutting edge. The buckets have one end flat. The flat end is what is called, tumblers. Buckets are rotated above this flat bottom of the tumbler as they move on the belt.

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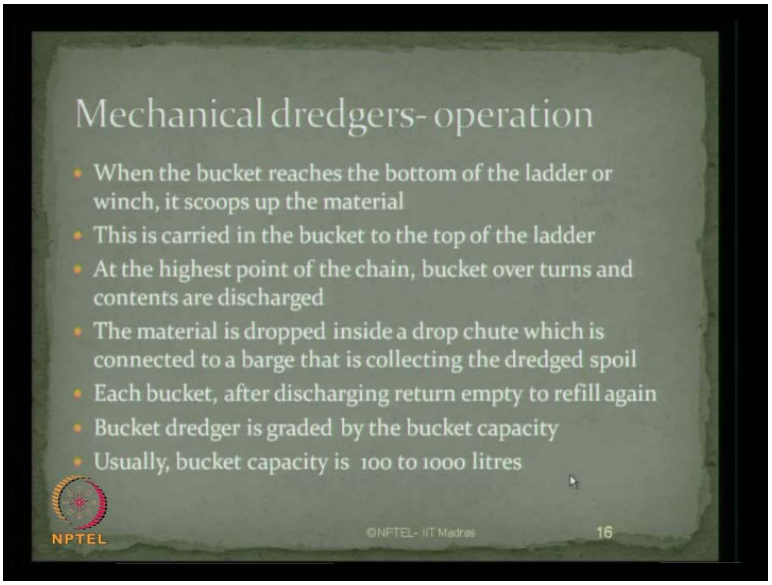

Let us quickly see how mechanical dredgers operate. When the bucket reaches the bottom of the ladder or the winch or the conveyor, as you see different types of model, it scoops up the material. This is then carried into the bucket to the top of the ladder or the conveyor belt. At the highest point of the chain, the bucket overturns and contents are discharged. The material is then dropped inside a drop chute, which is connected to a barge that is collecting the dredged spoil. Each bucket, after discharging, returns empty to refill again.

Bucket dredger is, essentially, graded by its bucket capacity; usually the bucket capacity is ranging from 100 to 1000 liters.

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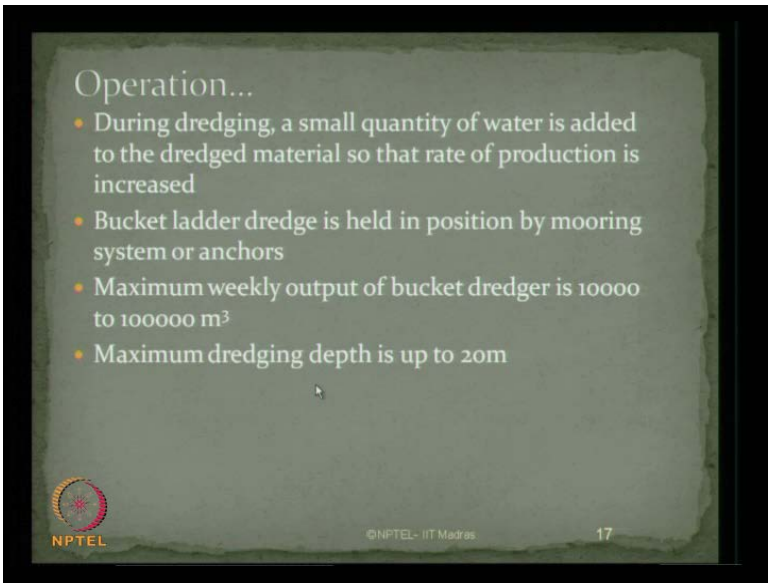


During dredging, of course, a small quantity of water is added to the dredged material, so that the rate of production can be marginally increased. Bucket ladder dredge is held in position by mooring system or by anchoring them to the sea-bed while dredging is carried out. Maximum weekly output of bucket dredger, as seen from the literature, is above, 100, 10000 to 100000 thousand cubic meter. Maximum dredging depth is up to 20 meter.

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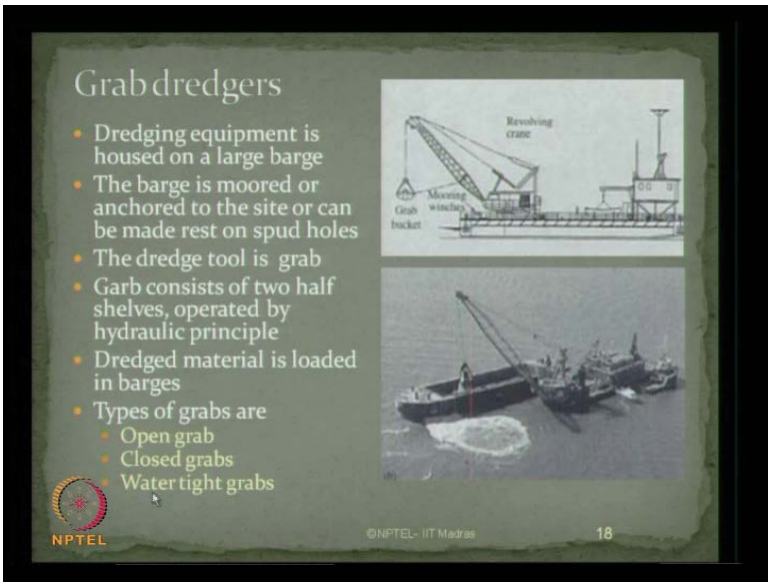


The other type of mechanical dredger, you see in the picture, is grab dredgers. Ladies and gentleman, as the name specifies clearly, the grab dredgers are nothing but where the mechanical dredgers have specific kind of grabs, which are replaced by the buckets. Dredging equipment is, of course, housed on a very large barge, as you see here, and this is actually the dredger, this is a grab, which is picking up the spoil material from the sea bed and discharging it on an additional barge, which collects the dredging spoil. The barge is moored to the site or anchored to the sea-bed or even can made to rest on spud holes.

The dredged tool used in the specific model is a grab, which you see here, this is called a grab bucket. This is nothing but a mooring line, which is anchored or connected to the winch. This is revolving crane, which can move practically 360 degrees around. So, it can do dredging, it can collect the spoil all around the area where it is being deployed. For example, this being the central area, this creates crane move around this, keep on collecting the dredge material from the sea-bed and keep on loading it on an additional barge located to the side of the dredger. The grab consists of two half shelves operated by hydraulic principle. The dredged material is then subsequently loaded in the barges, which is subsequently transported to one shore. The types of grabs, which are used in this kind of dredgers, are open grab, closed grabs and water tight grabs.

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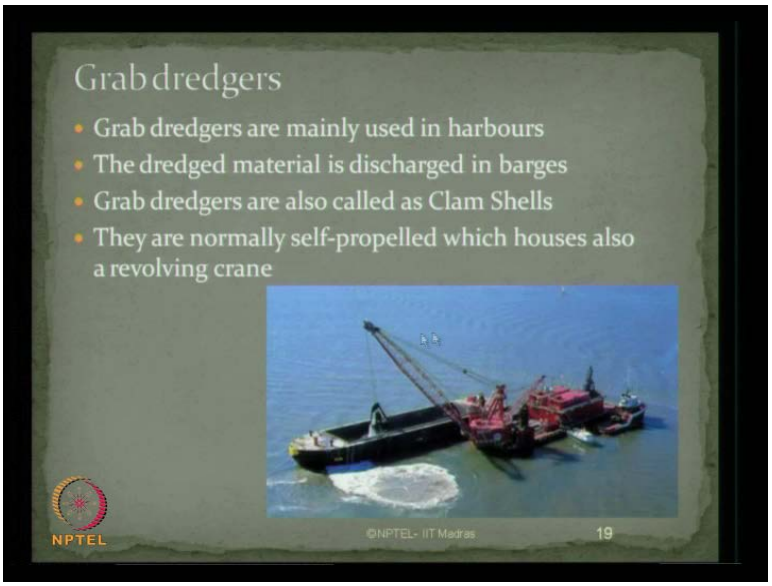


Grab dredgers are essentially used and commonly seen near harbours. The dredged material is discharged in barges, as you see in the photograph here. Grab dredgers are also otherwise called as clam shells. They are normally self-propelled, which houses also a revolving crane, as you see in the photograph.

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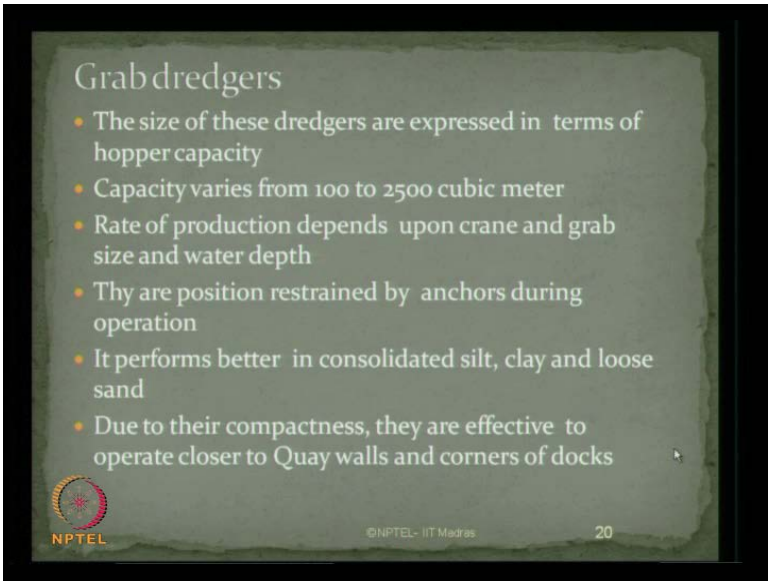


The size of grab dredgers is expressed in terms of hopper capacity. Capacity varies from 100 to 2500 cubic meters. The rate of production of these kinds of dredgers, essentially, depends upon the crane and the grab size and of course, the operational water depth.

They are position restrained by anchors. During operation, it performs better in consolidated silt, clay and loose sand. Due to their compactness, they are effective to operate closer to the quay walls and corners of the dockyards.

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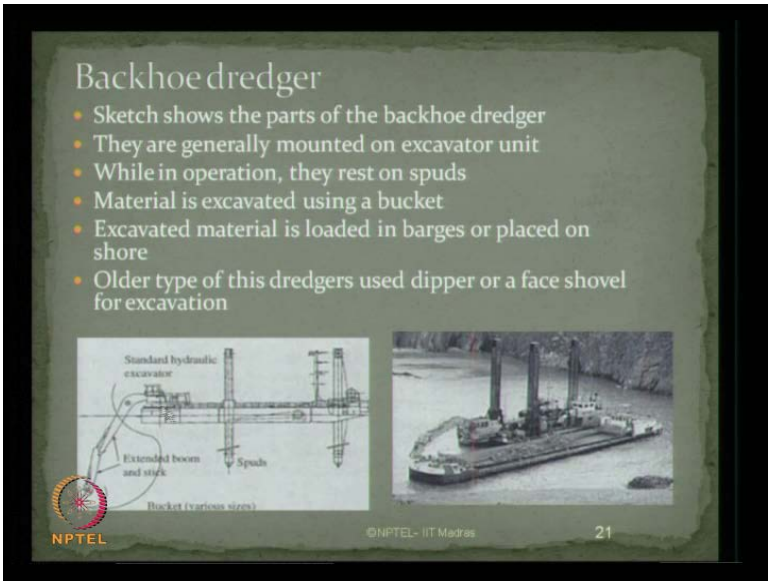


The other kind of mechanical dredger, what you see in the photograph here, is backhoe dredger. The sketch shows the different parts of backhoe dredger. As you see here, the dredger is position restrained using spuds. There is an extended boom and stick, which is used to the shovel attachment at the bottom of the bucket of various sizes, which are attached to the extended boom, which actually collects the dredged spoil from the sea-bed. The standing hydraulic excavator is also available on the dredger, which is helpful in loosening the dredge spoils. They are generally mounted on excavator unit. While in operation they rest on spuds.

As you see here, the material is excavated using a bucket, which is attached to the extended boom. As you see in the picture, the excavated material is subsequently loaded in barges or placed on shore direct. Older type of this dredgers used dipper or a face shovel for excavation. The modern varieties have an extensive, special kind of hydraulic excavator, which are attached and housed in the same barge where the dredge is equipped.

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Backhoe dredgers have bucket capacity varying from 0.5 to 13 cubic meters. They rest on spuds when they are in operation. As you see in this picture here, these are the two different legs, what we call as spuds, in operation. This is actually a backhoe dredger, which is used close to the coastline or to river line for doing some dredging operation.

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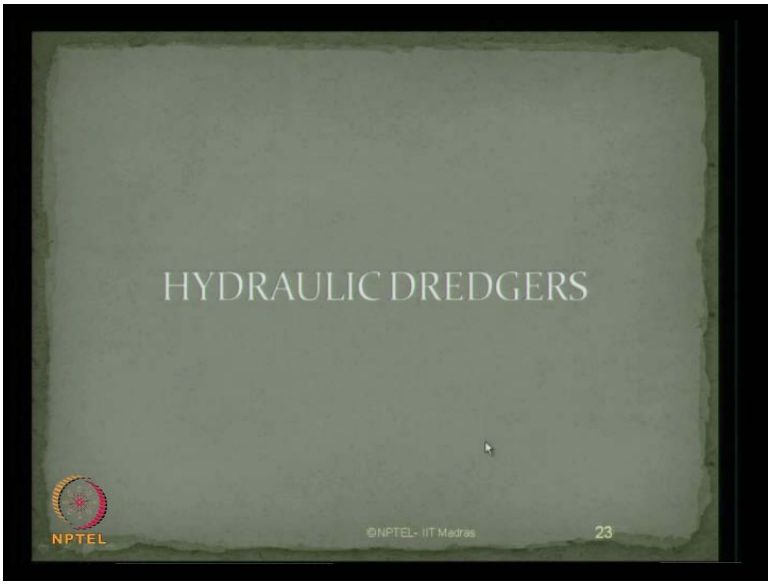

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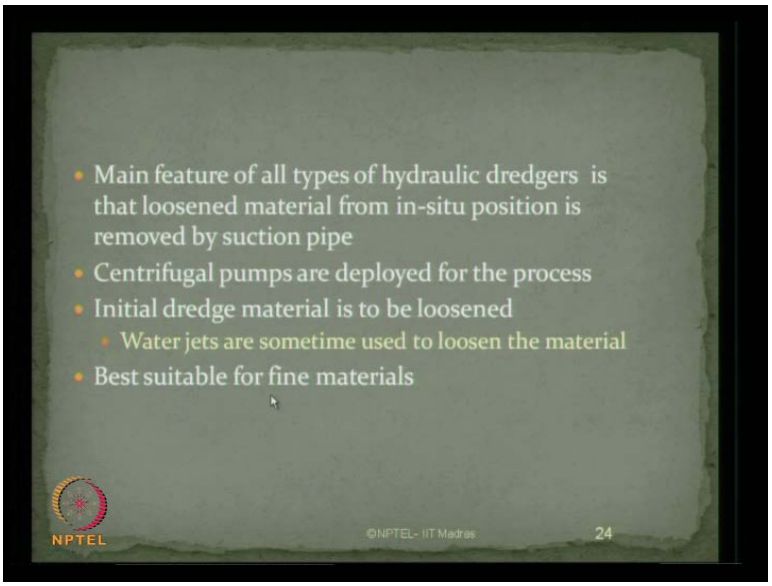


The second variety of type of dredgers other than the mechanical dredgers are, what we see now are, hydraulic dredgers. The main feature of all types of hydraulic dredgers is that the loosened material from in-situ position is removed, essentially, by a suction pipe. The hydraulic type dredgers, essentially, the material should be loosened on the sea-bed. Once the material is loosened, there are no buckets or hopper used to collect this material. People directly used suction pipes to transport this material from the site to the surface and subsequently, from surface to the barges.

Centrifugal pumps of larger capacity are deployed for the process. The initial dredged material is certainly to be loosened and reuse water jets to loosen the material. They are best suitable for very fine material.

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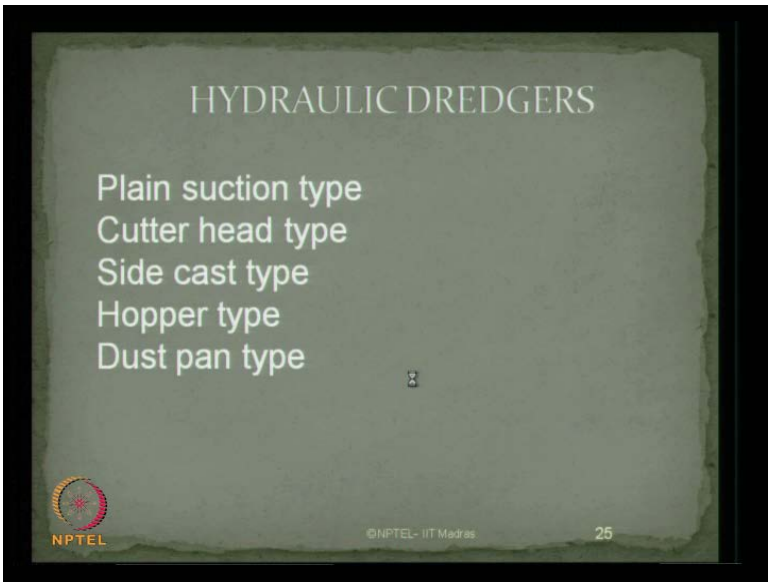


There are different types of hydraulic dredgers, as you see in the slide, plain suction type, cutter head type, side cost type, hopper type and dust pan type. Let us see one-by-one now.

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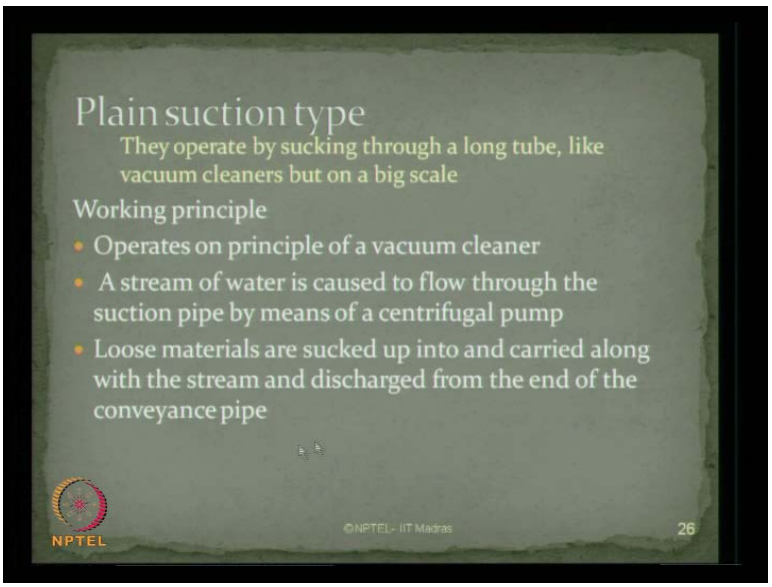


Plain suction type operates by sucking through a long tube, like the vacuum cleaner and of course, very large scale vacuum cleaners. The working principle of plain suction type is explained now.

It operates on principle similar to that of a vacuum cleaner. A stream of water is caused

to flow through the suction pipe by means of a centrifugal pump. The loose material are subsequently sucked up into and carried along with the stream and discharged from the end of the conveyance pipe, which is being used for barges.

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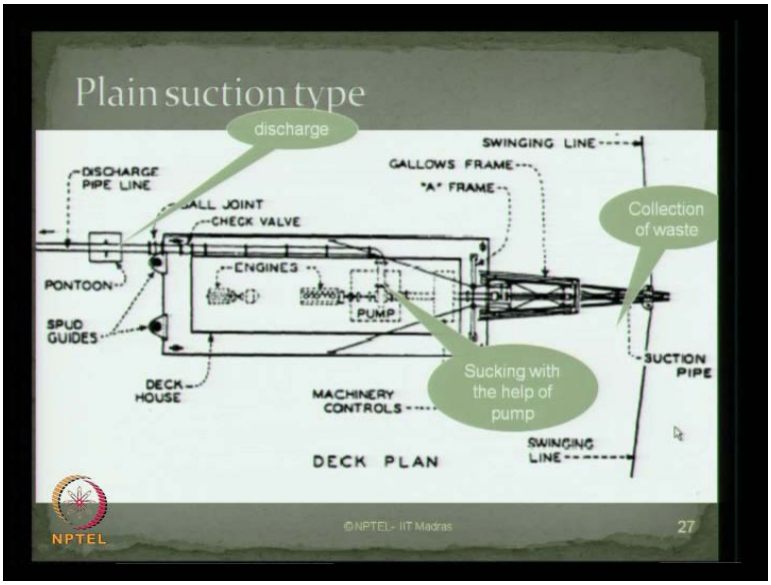


This is schematic view showing the components of plain suction type. You can see here, there is a pump, which is used for applying pneumatic pressure or hydraulic suction on to the pipes. This is extended boom line, which has got swinging line, which can also move laterally and peripherally along the dredgers. The suction type is attached to this where there is a gallows frame, which is housing this suction line, and swinging line stability is assessed and controlled by the gallows frame, which is subsequently attached to the A frame on the dredgers. The machinery controls and the hub are located here, which is used to control the operation of the suction, as well as, the movement of swinging line latterly and longitudinally with respect to dredger alignment.

This is self-propelled engine, engines are located in the real site of the dredger, as you see in this figure, and of course, the line is also connected from the pump. This pushes off the collected dredged material to the course, which we call discharge pipe line. Of course, during the operation this kind of dredgers rest on spud guides, which are being used for resting them or housing them on the sea-bed or on the river. The whole assembly where the mechanical equipment is kept what we call as deck housing. Here, the waste is collected, here it is sucked with the help of pump and then here it is

discharged. So, there are three different stages of operation happening in plain suction type: collection of waste, sucking with the help of pump, and then discharging it either to a barge or to the shore depending upon where are you doing your dredging.

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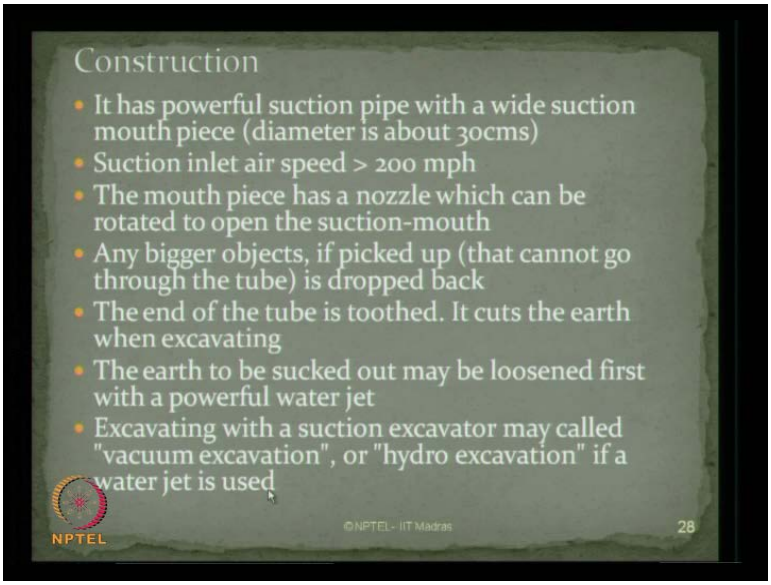


So, this kind of dredgers has very powerful suction pipe with a wide suction mouth piece. The diameter of this mouth piece is usually 300 millimeter. The suction inlet air speed is much higher than 200 miles per hour, so very heavy, heavy type engine. The mouth piece has a nozzle, which can be rotated to open the suction mouth. Any bigger objects, if picked up, cannot go into the tube, can be dropped back by the control mechanism, which has got sensor activated controls. The end of the tube is, of course, toothed, it cuts the earth while excavating and loosens.

The material, where to be sucked out, is first loosened with powerful water jet, subsequently evacuating with suction excavator, which we called as vacuum excavation or hydro excavation if water jet is used for the principle.

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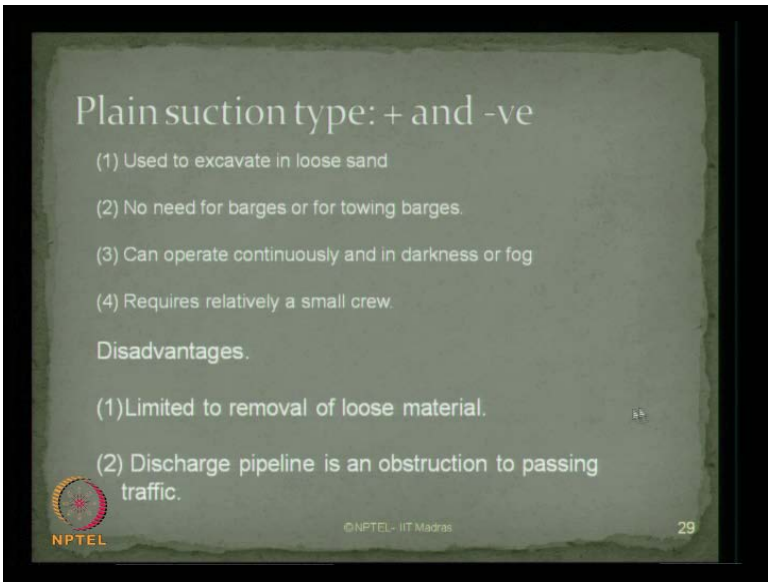


There are some advantages and disadvantages of plain suction type. The merits are, of course, used to excavate and loose sand; no need for any barges or for towing barges; can operate continuously even in darkness or even fog weather; it requires relatively a very small crew.

The disadvantages are: it is limited to removal of loose material only; the discharge pipeline is generally seen as a major obstruction for the passing traffic when dredging is going on.

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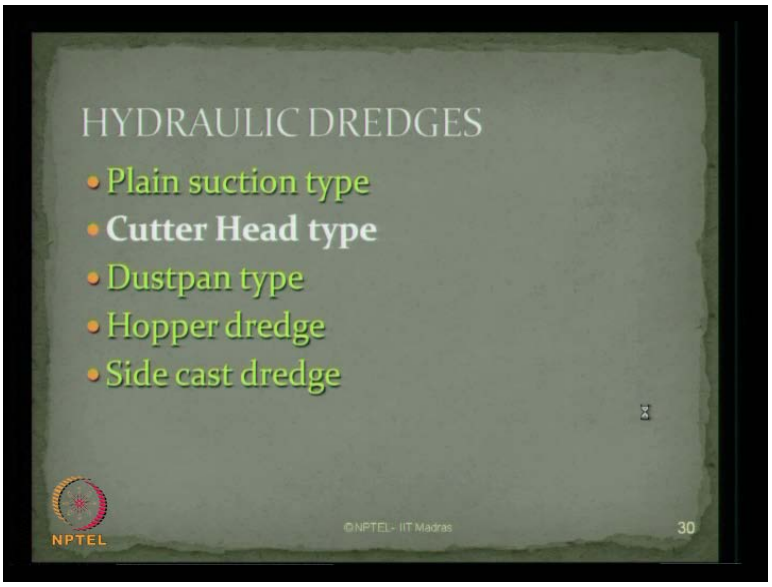

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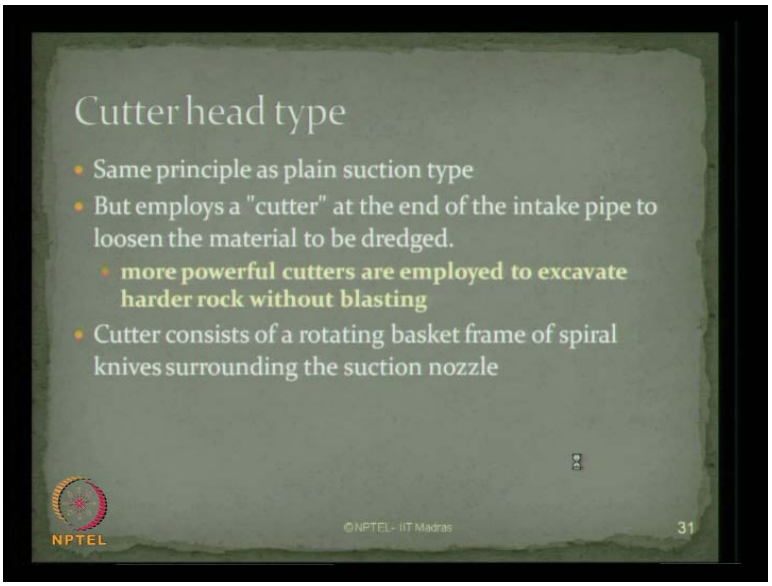


The next type, what we see here, is cutter head type. The cutter head type works the same principle as that of plain suction type, but of course, it employs the cutter at the end of the intake pipe to loosen the material that is to be dredged. These kinds of dredgers are more powerful because they are very high duty cutters, which are employed to excavate harder rock even without blasting. Cutter consists of rotating basket frame of spiral knives surrounding the suction nozzle.

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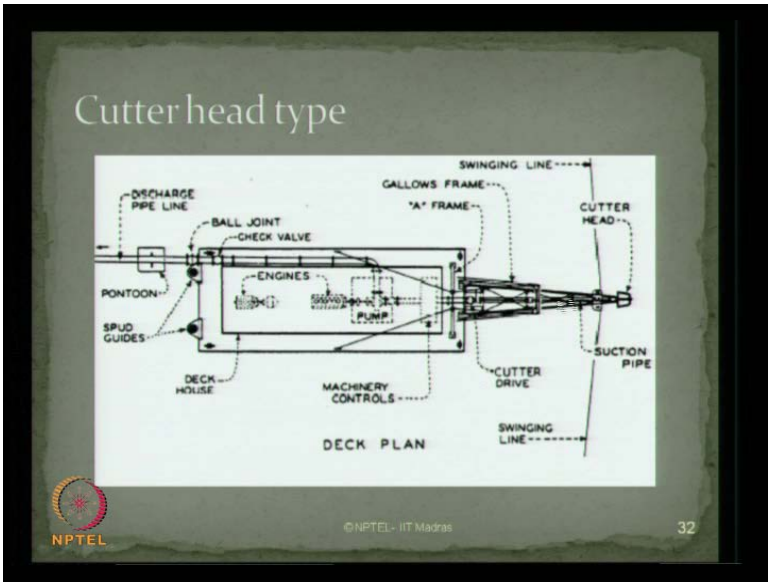


The figure, what you see here, shows the components and parts of the cutter type head

where you can see, here the cutter drive is attached, which was not present in the earlier picture and there is a cutter head, which is projected from the gallows frame where the swinging line are attached. This rotary drill, which has a nozzle cutter, which keeps on loosening the material, in fact, it even loosens harder rocks. Subsequently, the suction tube sucks them, discharge them inside, wherever you want to do so.

The additional alteration what people have done in cutter head type is a cutter head is attached to the gallows frame at the tip where cutting is first done, loosening is done, then sucking is done.

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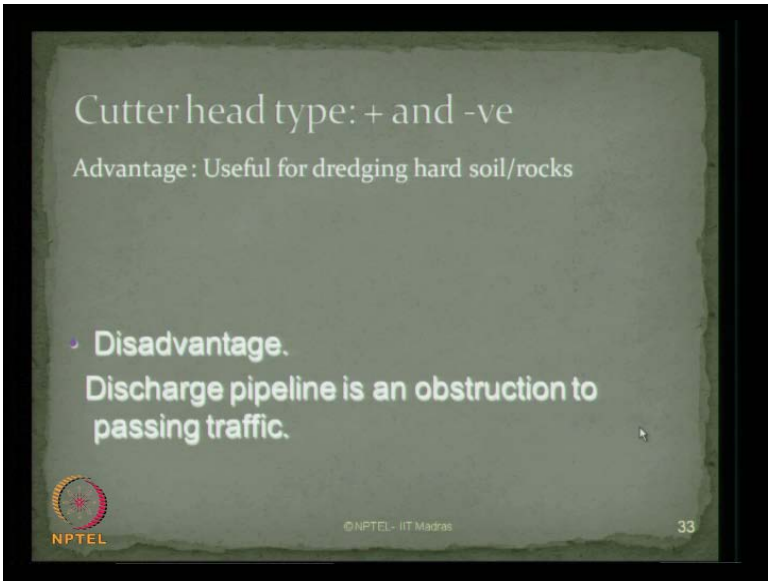


There are merits and demerits of this kind of dredger. They are useful for dredging hard rocks and soil. The disadvantages, of course the discharge pipe line is a major obstruction to the passing traffic when dredging is taking place.

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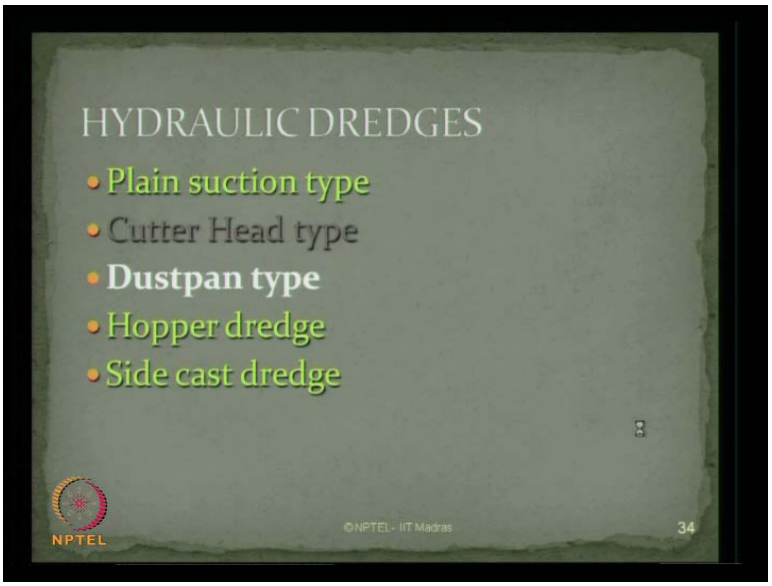


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The third type of dredger, what we see now, is a dust pan type. The dust pan type is shown in the photograph here. Ladies and gentleman, easily understand, that the tip where dredging taking place has got a special type of shovel, what we call as, a dust pan.

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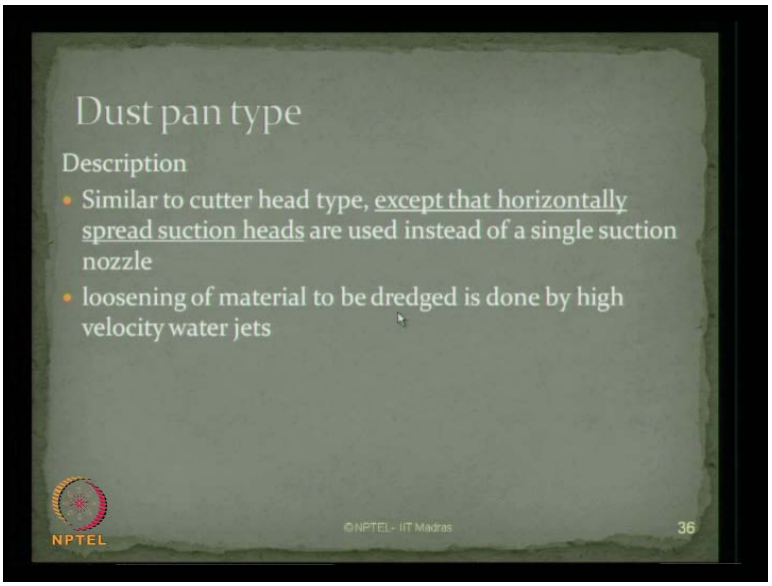


The dust pan type is similar to cutter head type except, that horizontally spread suction heads are used instead of a single suction nozzle, as you saw in the previous model. It is helpful in loosening the material. It first loosened the material to be dredged by high velocity water jets.

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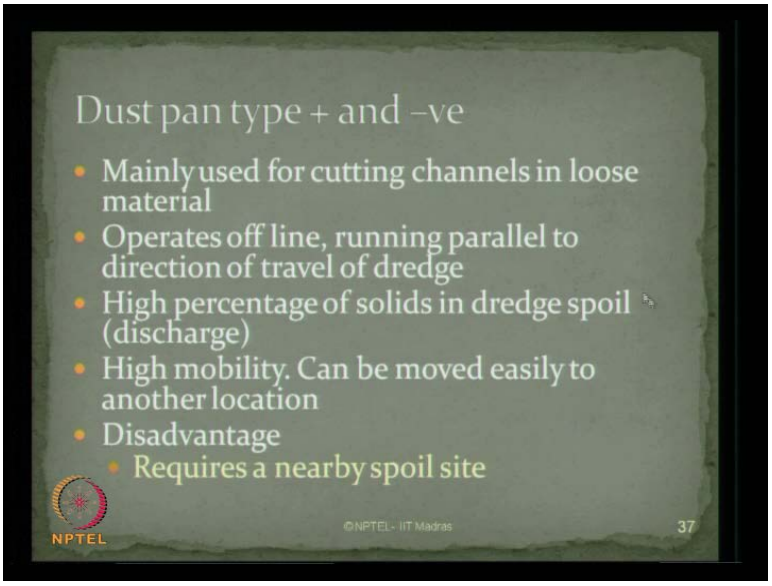


There are many merits and demerits of dust pan type. It is mainly used for cutting channels in loose material. It operates off line, running parallel to direction of travel of dredge. High percentage of solids in dredge spoil is seen, high mobility because it can be

easily moved from one location to another location.

The main disadvantage is it requires a nearby spoil site, because the dredge spoil contains high percentage of (( )).

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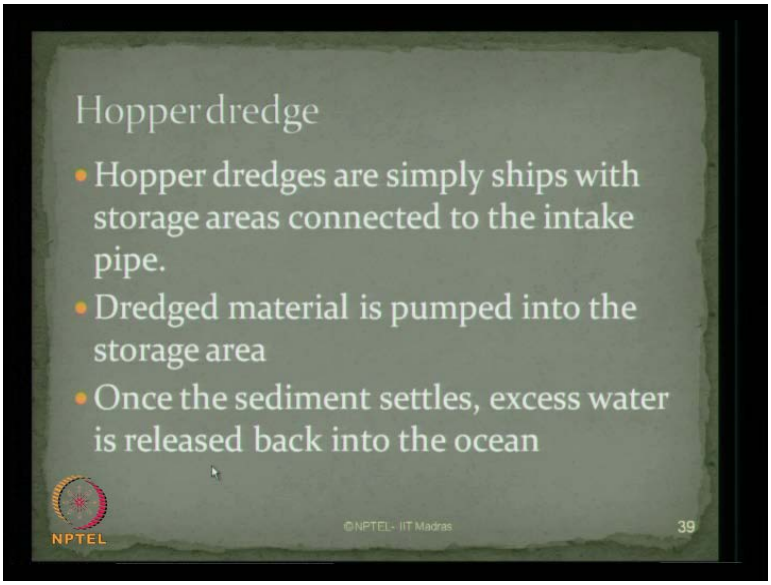


The other type of section dredger, what we see now, will be the hopper dredger. Hopper dredges are simply ships with storage area connected to the intake pipe. The dredged material is pumped into the storage area. Once the sediment settles, the excess water is released back into the ocean and then sediment is discharged.

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What we see here is a half filled, half-filled hopper, which dredges it on to the barge, where barge is filled with dredge material and water. When the sediments settled off, this water will be discharged and drained off from the barges. The settled sediments will then get disposed off to the site where dredge spoil or otherwise deposit.

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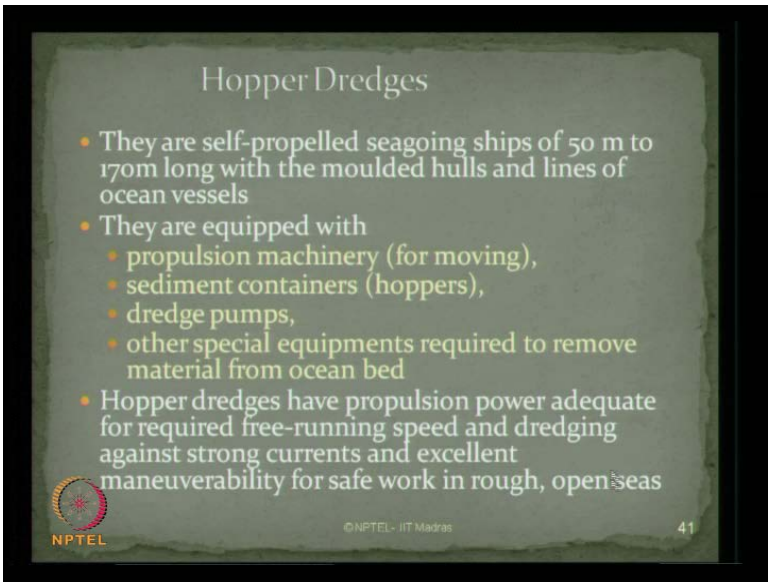


They are, essentially, self-propelled sea going ships of length varying from 50 meter to 170 meter. They have molded hulls and lines of ocean vessels. They are equipped with propulsion machinery for moving the hopper, has sediment containers, the dredge pumps and other special equipments, which are required to remove the material from ocean bed.

Hopper dredges have propulsion power adequate for required free-running speed and dredging against strong currents. They have an excellent maneuverability for safe working even in rough, open sea conditions.

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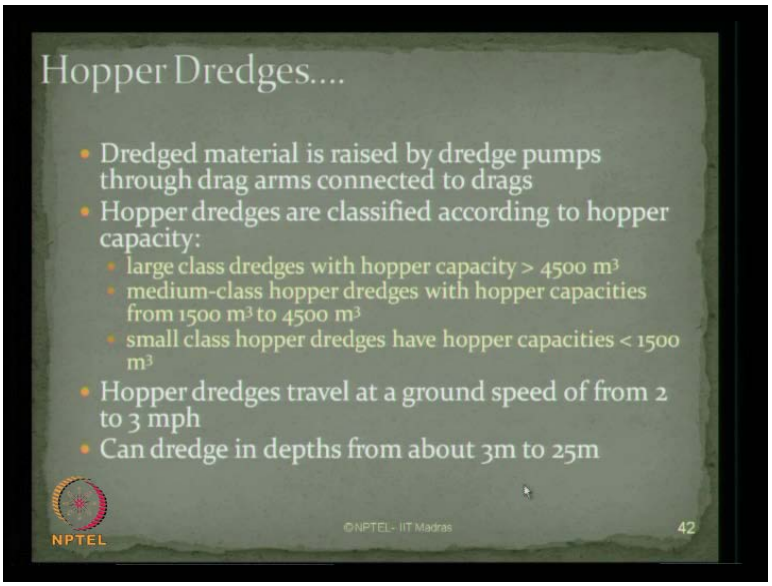


Dredge material is raised by dredge pumps through drag arm, which is being connected to drags. The hopper dredges are classified, essentially, based upon hopper capacity. The large class dredges with hopper capacity moved on 4500 cubic meters; the medium class dredgers have hopper capacity varying from 1500 to 4500 cubic meters. Of course, small class has capacity less than 1500 cubic meters.

Hopper dredges can travel at a ground speed of above 3 miles per hour. They can dredge in depths varying from 3 meter to the deepest 25 meters.

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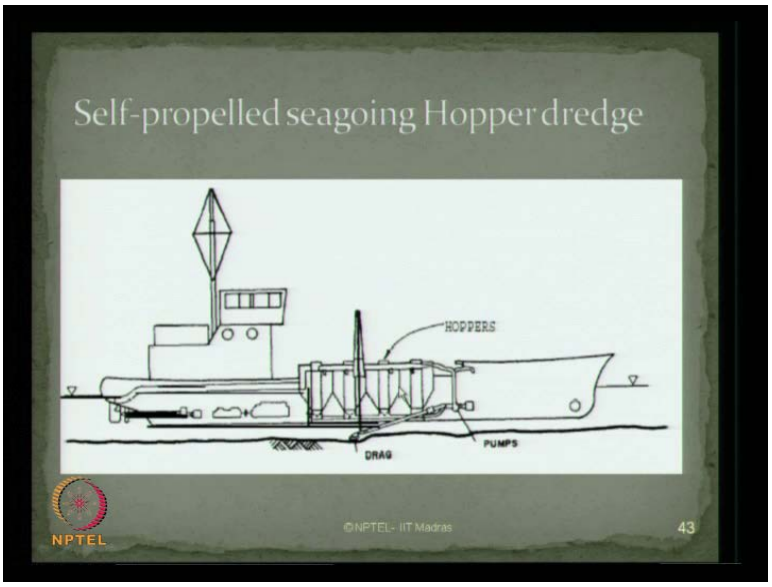

The picture, what you see here, is self-propelled seagoing hopper dredge. These are the hoppers, which fills dredge material, which is collected and suck from the sea-bed.

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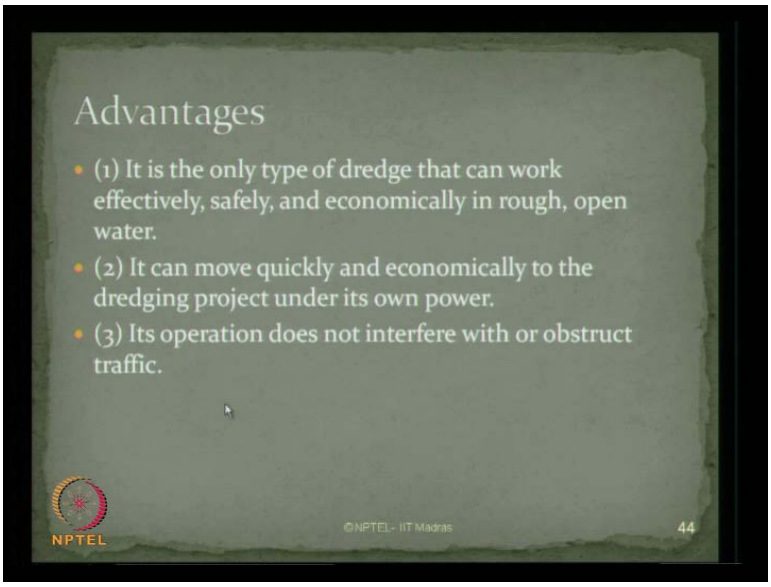


There are advantages and disadvantages of this kind of dredges. It is only type of dredge, which can work effectively, safely and economically even in rough open waters. It can move very quickly and economically from one side to another on its own power. Its operation does not interfere with obstruction of traffic.

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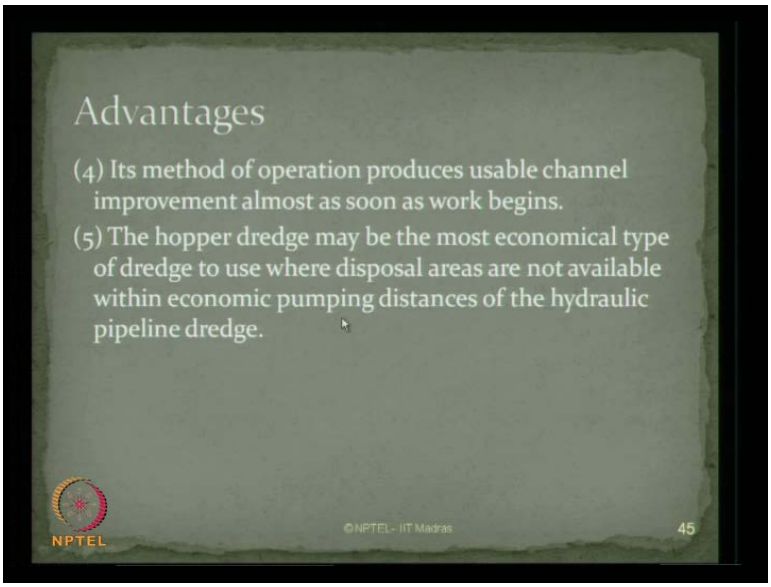


Its method of operation produces usable channel improvement almost as soon as the

work begins. The hopper dredge may be the most economical type of dredge to use where disposal areas are not available within economic pumping distance.

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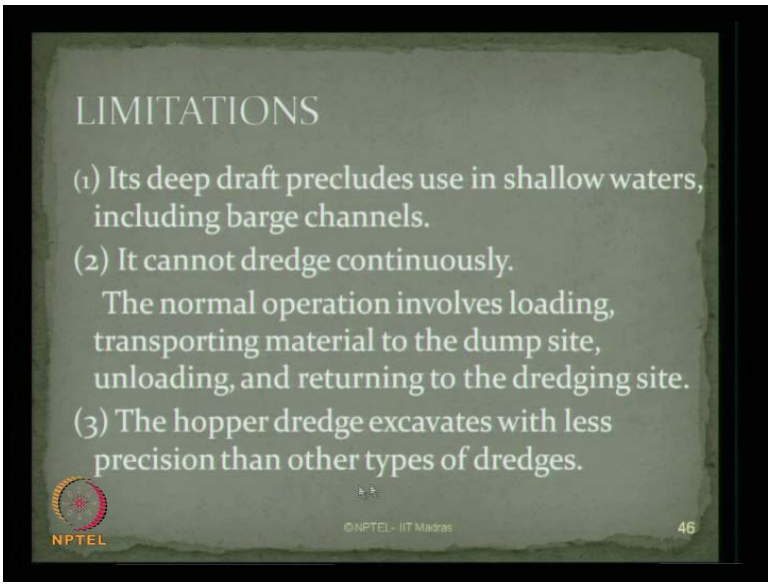


Of course, this type has serious limitations. Its deep draft precludes use in shallow waters, including barge channels. It cannot dredge continuously. The normal operation involves loading transporting material to the dump site and unloading and returning to the dredging site.

So, operation of this kind of dredger is intermittent, it is not continuous. The hopper dredges excavates with less precision compared to other kind of mechanical dredges.

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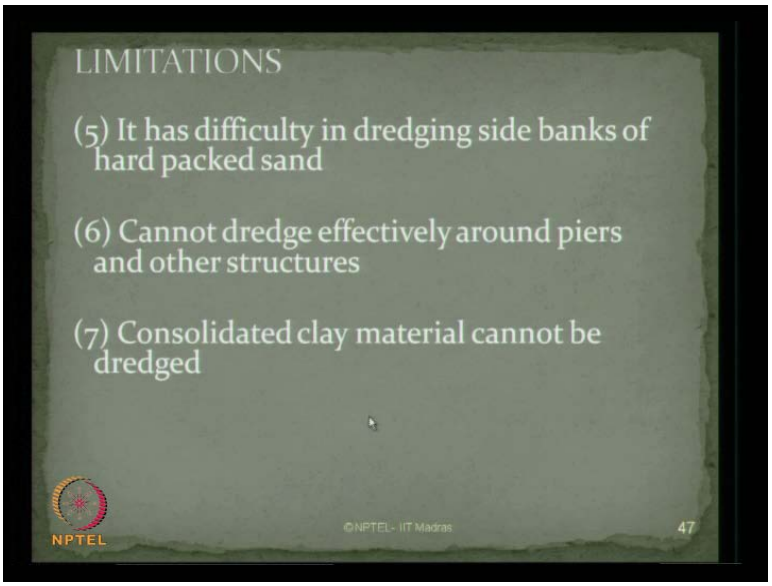


It has difficulty in dredging side banks of hard packed sand. It cannot dredge effectively around the piers or pipes. The consolidated clay material cannot be dredged using this kind of dredger, unless otherwise, it is loosened by some water tanks. We will see now a video where I will show you the mechanical working of different kinds of dredges before I close the lecture.

Ladies and gentleman, this is one kind of mechanical dredger, which is shown in the video. Now, you can see, the dredger is taken to the place where the dredging has got to be done. The suction pipes are lowered to the sea-bed with water jet. They are first loosened and then the loosened material is collected by suction pressure on this suction pipes. The suction pipes collect the material and forced them in this barges and extra water are drained off except, that they get settled down. Once it is done, the material is transported to shore using these facilities. You can also do this transportation using free floating pipeline, as you see in the video, or it can drop directly on the required mentioned side by spraying through the nozzle, the dredge spoil, as you see in the picture here.

The other kind is an hopper dredger, which has got hopper or bucket, which has got cutting edge. You can see cutting edge here in the video. This collects the material of rocks along with water and depositing it in barge.

The third type is clam shell dredger, which has got two (( )) where you can see the clam

jets inside collect the dredge spoil and then lift up using the hoop operation provided by the crane in the dredger. You can see dredge spoil is collected inside the hopper, which has got cutting edge as well. This is further transported to barge or to any other facility where this dredge spoil is to be stopped or collected. You can see it is dropping the dredge spoil and then the hopper returns back for successive operation or successive cycle. So, it is having two hops where hops get separated and there is a cutting edge. You can see now very clearly in this view. Once it is done, the clam closes and it is ready for the next cycle of operation.

Thank you.