

Work System Design
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Lecture - 26
String Diagrams

Hello friends, welcome to session 26 of our course we are now entering into the 6th week of discussion. We have already completed 5 weeks of discussion and in 5 weeks we have tried to cover the basic aspects of work study we have covered the various aspects of productivity. We have started discussion on method study which is one of the most important techniques which is employed to improve the productivity of our organization.

In method study currently our focus is on learning the various graphical tools that helps us to examine the current method of doing the job. As well as we are trying to see that how the method can be improved, So, we have divided our discussion of method study into 2 broad areas, the first broad area is we want to learn that what can be the various graphical aids graphical tools in which we can with the help of which we can represent our current method of doing the job.

Moreover, when we have different alternatives we find out a better solution, we find out a better alternative for doing the job. We again draw the graphical tool the graphical can be operation process chart, it can be a flow process chart, it can be a 2 handed process chart, it can be a multiple activity chart different types of graphical tools depending upon the area of work that we are focusing upon.

For example, we are focusing on the overall plant we can refer to the operation process chart we are seeing how a person is operating a machine or multiple machines. We can focus on a multi activity or a man machine chart. When we want to analyze that how the person is doing the work all his limbs how he is using his hands, how he is using his legs we can refer to a 2 handed process chart.

So, depending upon the type of work being done we can identify we can select a particular graphical tool. And in that context only we are trying to learn the various tools and techniques

that can help us to examine the current method of doing the work. After we know that these are the various tools and techniques we will see that how critically we can we can examine that how the work is being done and we can ask different types of questions related to the current method.

Which will help us to formulate alternatives which can be better than the current method of doing the job. So, when we study method study or when we try to understand or when we discuss that topic of method study our prime motive is to first understand that what are the various graphical tools which can help us to examine before examining record the current method of doing the job.

Or to put on paper the current method that we are following after that we try to formulate new methods we would try to brainstorm new method we try to create new methods, we try to innovate new methods and these new methods may be better than the existing method and then we compare that to method. Suppose we have drawn an outline or operation a process chart for the current method then we innovate we find 4 new methods.

We find that this one is giving us a better savings it is a more efficient more effective we try to put that method also in the operation. Or we try to draw an operation process chart for the improved method also then we compare the 2 and we find out what our savings savings can be in terms of less number of operations, savings can be in terms of less number of inspections, less transportation, less effort of the worker.

Less number of people required to accomplish the task less money involvement or less it is economical point of from money point of view. So, the benefits can be numerous in that summary also in that line today our topic is string diagrams. So, we have already if we can revise what we have covered in method study we have already seen the operation process chart we have seen the flow process chart.

We have seen different types of flow process charts, we have seen 2 handed process chart we have seen multi activity chart flow diagrams and today our target is string diagram. So, in that discussion we will first learn all these tools and techniques then we will try to see that once we

have depicted the work how we can develop a better method how we can critically examine the current method of doing the job.

Then once we find out number of better methods we will compare them and then we will install and maintain those methods. And if you remember in one of our previous session in the very beginning of method study. We have seen steps of method study in which we have seen that there is stepwise procedure there is a stepwise procedure which can be followed to truly realize the results are truly realize the benefits of conducting the method study.

If we do the things systematically following the procedure following a step by step procedure it will help us to truly realize the potential of conducting a method study. So, therefore in that summary today our target is string diagrams. We will try to understand what is a string diagram how we construct it and what can be the benefits of constructing a string diagram. So, on your screen you can see this is the introduction of the string diagram.

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String Diagram: Introduction

- String diagram is one of the **useful** and **simplest** techniques of **method study**.



Source: Introduction to work study, ILO, Geneva

The string diagram is one of the useful and simplest techniques of method study. We have already seen some of the graphical tools which are used in method study. String diagrams also one of the techniques and it is most simple most easy so here you can see these are the pins which are we can say one of the important points or important tools that we use in conducting a method study using string diagram approach.

So, these are these can be the various shops the dark portions and then with the help of a string we try to mark or we try to identify the movements of the man and the material. This is just may be say introductory diagram of how string diagram would look like it would look like this there will be pins and there will be string. So, this is we can see a pin and this is a string and therefore the name string diagrams.

So, the name is from the string or the thread that we use for depicting the movement of the men and material in the workshop. So, the basic definition for string diagram can be.

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String Diagram: Introduction

- The string diagram is a **scale layout drawing** on which a **thread or string** is used to **record or trace the paths** of workers, materials or equipment during a specified sequence of events.
- Thus, the string diagram is a **special form of flow diagram**, in which a string or thread is used to measure the distances.
- Because of this, it is necessary that the string diagram be drawn correctly to scale, whereas the flow diagram is drawn approximately to scale.

The string diagram is a scale layout drawing this is important we have seen the flow diagram also which is approximate to the scale but the string diagram is as far as possible to the scale only. So, string diagram is a scale layout drawing on which a thread as I have already mentioned or a string is used to record or trace the paths of workers, materials or equipment during a specified sequence of events.

So, basically suppose a person is serving food in a restaurant so the person who is serving food in the restaurant his movement from the kitchen to the table to the counter all that it can be traced using a string. And how the string will be wound with the help of pins or panels or pugs that we put at different places. So, suppose the worker or the person working in the hotel or in the

restaurant takes food from the kitchen.

So, one string can depict the movement he goes to table 3 gives the food there then he is getting a soft drink also he offers that or gives the soft drink at another table. So, that movement will be traced then he goes to the counter takes the bill for a particular table the string will go to the counter and then he goes to a table and or gives the bill there. So, that the movement will be recorded.

So, the string diagram will record the movement in this case of a man who is working in a restaurant with the help of a string for example automatic guided vehicle is operating in a automatic factory. So, the movement of this equipment which we are calling as a AGV can be recorded with the help of string and this will help us to follow to understand that what is the movement?

What is the area where there is a lot of congestion, what are unnecessary movements of the men and material all that can be identified with the help of string diagram? So, we can see again I will read it for you because this will make the things very very clear that the string diagram is a scale layout drawing so that it has to be as per the scale on which a thread or a string. So, what do we need to do what do we need require for making a string diagram are the pins.

And string or a thread and it is used to record or trace the paths of workers, materials or equipment during the sequence of events. The string diagram is a special form of a flow diagram so flow diagram is also depicting the movement. If you remember in the previous session, we have seen that in flow diagram also we draw to scale approximately to scale the various shops or the various facilities.

And then we depict the movement of men and material it is same but that is to do drawing in which we depicted with the help of arrows and with the help of lines but here instead of lines we will be using a string. So, this we can say from 2D we are heading into the third dimensional also because string will be in the third dimension. So, this is a special form of flow diagram in which a string or a thread is used to measure the distances.

So, we do not know for example a lady is cooking food in the kitchen so she may be moving around in the kitchen maybe she may be out some time at the gas stove and other times she may be fetching some utensils from the almirah or a cupboard then maybe she is moving around in the kitchen. So, we do not know how much distance she has moved because if our kitchen is not properly designed there may be some unnecessary movement of the lady who is cooking food.

So, what we can do we can do a string diagram we can place the we can draw the kitchen to scale and then we can put over pins at the respective positions and then see that how many times she has moved for cooking a single meal and then we can think of redesigning the layout of the kitchen in such a way that her movement is minimized or optimized. So, in this case our major focus is the distance.

And the distance travelled or covered is measured using the length of the string. So, how we will first use a string to trace all the movements of the worker. Is worker our subject or if the equipment or material is our subject. We will trace the movement of the material in the industry with the help of a string this has to be a non-stretchable rigid string because it must not stretch because then the distance will be changed.

So, if we are having a rigid string we will trace the path then we will take this string or the thread and measure the distance that what is the total distance. And it is a scale diagram so there can be a scale that one centimeter=one meter or one centimeter=5 meters as per that scale we can calculate that what is the total distance traveled by man or the machine in the work area or in the work space.

So, basic purpose is to minimize their travel in the shop floor in any working area because of this distance that we are able to manage or measure it is a necessary that a string diagram be drawn correctly to scale which is very very important and which has already been highlighted in the basic definition also. The string diagram with a scale layout drawing so it must be exactly drawn to scale whereas the flow diagram is drawn approximately to scale.

So, since our target here to get here is accurate measurement of the distance travelled therefore the scale is very very important in the case of the string diagram. So, how it is useful as I have already explained I will read the sentences written on the slide for you.

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How String Diagram is Useful ?

- There are many **industries** in which the **worker moves in irregular intervals** between a number of points in a working area, with or without material.
- In restaurant, different persons serve the food to different tables.
- In **such type of condition**, a **string diagram is the most useful technique** for recording and examining the activities.

There are many industries in which the worker moves in irregular intervals between a number of points in a working area with or without the material. So, worker is moving at irregular intervals of time within different points as I have told you a worker a person is serving food on different tables in a restaurant. So, his movements cannot be repetitive it can be random also so those random movements can be raised with the help of a string.

So, he may be sometimes moving to the table without the material sometimes he will be moving to the table with the material or with the food item. So, those are maybe irregular movements of the worker just an example of irregular movement of the worker in the working area for example it is given in the restaurant the different person serves food to different tables. In such type of situation, a string diagram is the most useful technique for recording and examining the activities.

Because if you take a sofa or maybe a flow diagram the flow diagram can give us maybe one movement that suppose the raw material is entering from this window then there are 5 machines it is going to machine number 3 5 1 and then it is going over from the other door. So, flow of the

material in the shop floor will be depicted with the help of a flow diagram. But how many times we are doing it then again we have to modify overflow diagram.

And suppose it is another raw material which require a different sequence of operations than the flow diagram will change accordingly. So, the string diagram will help us majorly to record the may be you know maybe what is written here regular intervals when the person is doing the job that also can be easily depicted using a string diagram. To recall here our major objective is to measure the length of the string so the time scale is not that important in case of a string diagram.

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String Diagram Vs Flow Diagram

- **Scale:** String diagram is drawn **exactly on scale** while flow diagram is plotted **approximately on scale**.
- Distances may be **marked on flow diagram** but **not on string diagram**.
- Flow diagram would become **cumbersome** if too many too/fro movements are there, but the same will not affect much in case of string diagram. ◦

Scale the string diagram is drawn exactly on a scale while the flow diagram is plotted approximately on scale. This point already has been highlighted since it is important therefore may be depicting it again or we are highlighting it again. Distances may be marked on a flow diagram but not on the string diagram so maybe marked in many flow diagrams you may not have the distances but as a special case we can mark the distances also.

And if you remember in one of the case studies that we had taken a typist is moving towards the office a distance of 20 feet was marked on the flow diagram. So, maybe in special cases we can mark the distances also on the flow diagram but it is not required on the string diagram because we will measure the length of the string after tracing the path of the worker or the machine on the shop floor or in the working area or in the office or in the kitchen.

Wherever we want to optimize the movement and we want to redesign the layout based on the movements of men and material. So, the flow diagram would become cumbersome if too many to and fro this is the flow diagram would become cumbersome it becomes difficult if too many too and fro movements are there but the same will not affect much in the case of a string diagram. So, if you remember that in case of a flow diagram.

We are supposed a man or material not a moving through a single passage again and again the material or men are moving through the passage again and again we have to depicted with the help of a flow diagram too many movements of different types of man and material will make the flow diagram cumbersome. Although we have found out a remedy for that you can use different color arrows.

Or different color pens or different colored pencils to depict the movement of different men and different material but still we can trace the congestion we can trace the back tracking with the help of a flow diagram. But when too much of movement is there the flow diagrams becomes complex. Similarly, in case of string diagram we use the strings so slightly less complicated as compared to the flow diagram.

The flow diagram is cumbersome if too many movements are there but the same will not affect much in case of a string diagram we can very easily pull the string. We can have strings of different colors also or the threads of different colors can be used for depicting the movement of different subjects that is machines and workers or materials. Now purpose of string diagram again we are coming.

But here systematically we have tried to enlist or highlight that why do we need to draw objectives that can be met using the string diagram.

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Purposes of a String Diagram

- It represents the **record of an existing set of conditions** and thus helps the method engineers in visualizing the actual situation.
- It indicates **complex movements, back tracking, congestion, bottle necks** and over and underutilized paths on the shop floor.
- It **helps in tracing existing paths of movement** for incorporating necessary modifications, if any.
- **Indicates the pattern of movements** and thus helps in deciding the most economical routes to perform a particular operation.

It represents the record of an existing set of conditions and thus helps the method engineers in visualizing the actual situation. So, first we need to understand what is a string diagram how it can be drawn and what it can represent. So, this point is highlighting that what a string diagram can actually represent. Now I have taken an example of a person serving food in a restaurant so his movements for 2 hours.

Or maybe for 3 hours' duration can be traced using a string diagram which can help us to examine that how he is performing his task or how the layout can be changed or how is the responsibilities can be managed so that his movements are limited and he is able to perform his task in the most efficient manner. So, string diagram will help us to clearly understand the current method or the current movements of a worker or a material.

It indicates complex movements these are our questions we have we can easily identify these are the complex movement, we can identify backtracking, we can identify congestion, we can identify bottlenecks. So, string diagram going to help us to identify all these things. And when we are able to identify we can use over creative (()) (19:58) to find out how old these problems can be sorted out. How these problems can be solved?

How we can find solutions to these existing problems. So, string diagrams will help us to identify the areas of improvement that these are the situations where the system is lacking and needs

certain improvement and it will also help us to identify the over utilized passage or overutilized facility. And underutilized paths there may be a situation that all materials all men are taking a particular path only there can be other path to which is less traversed.

Or less taken or less utilized by workers in machine. Because they are not aware that that path can also be helpful or can help them to optimize their movement. In many cases we have seen and these days there are a lot of advertisements also that you can check on a mobile app. That if you are going from a position A to position B although your A to B distance from may be route P is shorter and from route Q it is longer but P may take more time because of congestion.

And the route Q may take less time between point A and point B. So, you can check before the movement there can be more traffic on route P less traffic on route Q. So, you will try to go through route Q. So, that the type of situations can easily be understood with the help of a string diagram and we will we can see that all strings are moving in this direction only. But there is another path which can be followed.

So, that will help us to further optimize the movement of men and material. So, under-utilized paths can be found out using the string diagram it helps in tracing the existing paths of movement for incorporating necessary modifications if any. Which is an off shoot of the second point only which I have already explained. Indicates indicates the pattern of movement thus helps in deciding the most economical routes to perform a particular operation.

So, pattern of movement may also add into a pattern of movement means that how a person is performing or what sequence of operations he is doing or what is the pattern of his movement on the shop floor can easily be identified with the help of a string diagram. Now we know that if we construct a string diagram we can optimize the distances travelled by the worker or the machine or the equipment which will make his life easy which will optimize over operation and resources.

Therefore, we must construct a string diagram and try to optimize our layout, how to construct another next maybe 2 or 3 slides will help us to construct a string diagram. First is study and record of the complete first thing is we must understand how the work is being done to study and

record the complete information about the movement of various resources.

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Construction of String Diagram

- **Study** and **record** the complete information about the movement of various resources.
- Draw a **scale layout** of the shop area and mark various features such as **machines, work benches, stores** etc.
- **Mark** and **insert panel pins** at all workstations between which the journeys are made.

What are the resources, resource can be men, resources can be material or the resources can be equipment? So, we have to see the movements of all all these 3 resources that how all that is of how the resources are moving in the shop area or in the shop floor. Draw a scale layout this is very very important if we have to focus on scale because later on we have to measure the length of the string to find out that how much distance has been traveled by the worker on the shop floor.

So, then we have to draw the scale layout of the shop area and a mark the various features as machines, work benches and stores. So, we will see the example that how these are if you remember the very first slide that we have seen during the introductory slide there was one layout of one shop floor and black portions were depicting the various shops and there were pins through which the thread was tracing the path of a worker or a machine.

So, that all facilities have to be laid out on the drawing or on the layout. Mark and insert the panel pins at all the work station between which the journeys are made. So, we have to mark the pins at the various stations for example a person is going to ophthalmologist to get his eyes checked. So, he has to first go to maybe one section get his eyes checked go to the next section where particular may be specs or the glasses will be checked.

Then he has to maybe go to select the frame then he has to go to make the payment so if he enters we can put the pins at each position first we can make a layout layout of this complete ophthalmologist clinic and then we can trace the movement of the worker we can put the pins there and take a thread and that thread can depict the movement of the worker.

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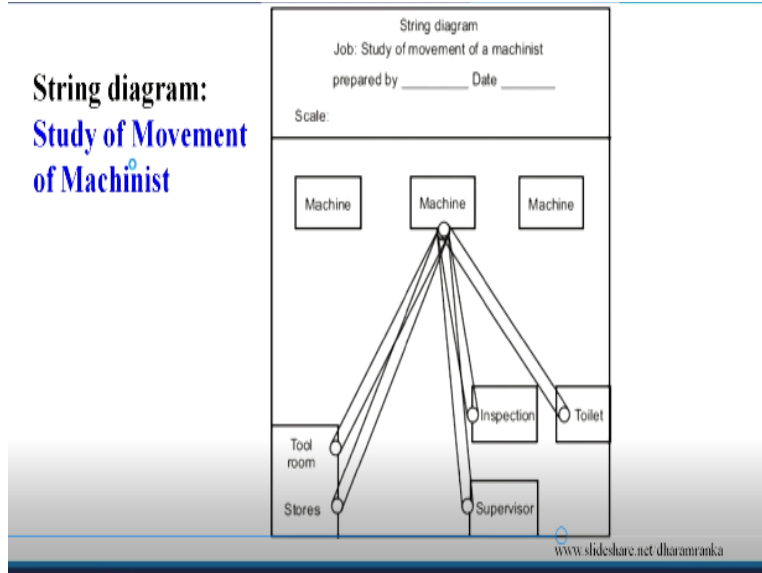
Construction of String Diagram

- Use strings/threads of different colors if the movement of more subjects is being shown so that their movements are easily recognized and distinguished.
- Remove the string to measure their lengths which approximately gives distances traveled by a worker or a machine or the material.

These are the pins then use the strings threads of different colors is this I have already explained strings and threads of different colors. If the movement of more subjects more number of workers, more the number of machines or more the number of material is being shown so that their movements are easily recognized and distinguished. Remove the string to measure their lens which approximately gives their distances travelled by a worker or a machine or the material in the shop floor.

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String diagram: Study of Movement of Machinist

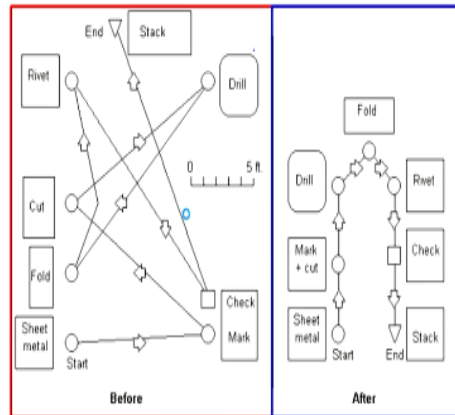


Now this is one string diagram that is study of movement of a machinist and you can see it is a string diagram where job study of movement of a machinist. So, this is a machine this is their tool room this is a machine these are the stores so he has to go to the supervisor also inspection also toilet also. So, this this this is a string basically and this is the pin on which we can say rotating or we can say marking the machine.

So, this is a pin on the pin this is the pin this is the thread so we will take the string and bend it over the pin and then take it to the next pin and wind it over there take it to the next pin where he is moving wind it over there and this way we will be make a complete tracing of the path with the help of a string and with the help of a pin. So, the pin we will wind like this and we will be able to trace the complete path of the worker.

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**String diagram of
A Metal Worker During
The Manufacturing of A
Metal Box**



Note :

- The initial diagram on the left, shows the path of motion of the metal worker that involves several unnecessary movements.
- Considering the string diagram, a more efficient and economical path for the movement of worker is developed to avoid unnecessary movements and to ease accessibility.

www.ijcnet.archive.v5i8.ART20161250.pdf

Now this is another we can see current method or before and how we have redesigned the layout that is after. So, here if we can see this is start the movement is depicted by these arrows so start goes to the marking section from marking it goes to the cutting section from cutting to the drilling section from drilling it goes to the folding section. The arrows are shown here then to the riveting then again to the checking and then to the stack or to the storing.

The process chart symbols are shown here this is the movement and a very easily if you focus on this slide you can very easily using common sense see if we measure the length of this thread or the movement of the worker the length of will be quite large as a compared to the length of this string that we are measuring. So, if this is depicting a movement of the worker so what is this chart for?

It is a metal worker during the manufacturing of a metal box it is depicting the movement of a worker. So, in the current method or before the different facilities are located randomly and the worker has to move through all these facilities to make this or to manufacture this metal box. So, if we can re layout we can change the layout of all these facilities for cutting and drilling and riveting and sheet metal approaching if we can redesign them in a U pattern like this.

So, the movement of the worker is reduced and he or she becomes much more efficient. So, here we can see the notes are given the initial diagram on the left shows the path of motion of a metal

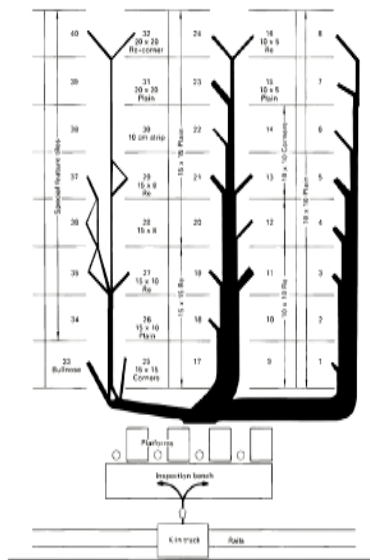
worker that involves several unnecessary movements. This we want to avoid how we can avoid considering the string diagram a more efficient and economical path for the movement of the worker is developed to avoid unnecessary movement to.

And to ease the accessibility of the various facilities so this one is much more you can say efficient and effective as well as productive method of doing the job of manufacturing a metal ball. Whereas on this side it is a cumbersome method the unnecessary movement in the shop floor of the worker why because the facilities are located in haphazard manner not in a systematic manner and such type of situations are there in most of the industries.

If we use common sense and use tools and techniques like like the string diagram or the operation process chart we can certainly relocate the facilities certainly redesign the method of doing our work which is much more efficient and effective. So, here this is just one example the other example can be.

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**String diagram:
Storing Tiles
(Original Method)**



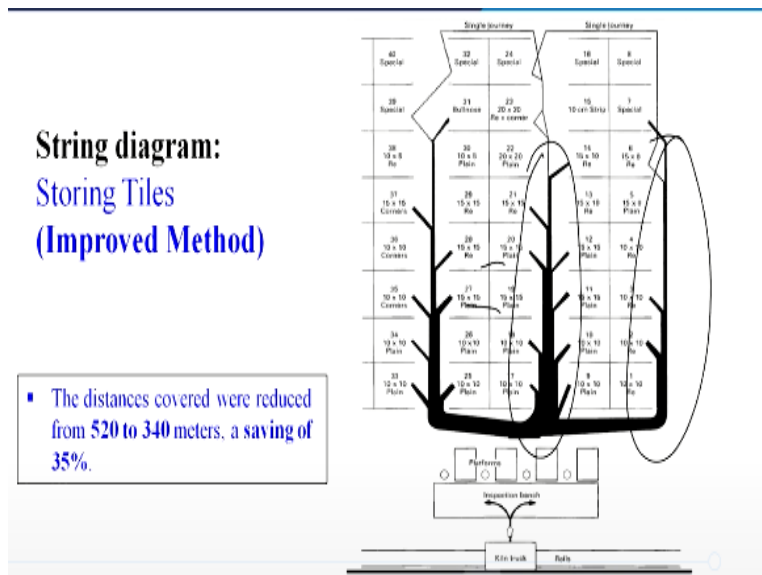
Source: Introduction to work study, ILO, Geneva

This is the original method of storing the tiles in the store so here we can see this is a truck from where the tiles are coming this is the inspection happening there then they are placed in the platforms and the platforms are placed on the various locations, So, it was found out this is a case study from introduction to work study the ILO book which we are currently following for taking different examples.

You can read the details about this problem there if you have the ILO book or you can get it issued from the library or where institute library it is a very famous book on work study. This is a problem it is explained in much more detail there so here there is no specific place made for storing their titles but then analyses were done that which are the most common sizes for the tiles and which are the special sizes for the tiles.

And so a classification was done based upon the sizes of the tiles and then the layout was changed and you can see this is showing this dark portion is showing the strings or the movement for storing the tiles in the warehouse.

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And this is considerably reduced by changing the re layout. So, you can see the thickness has reduced which means the movement has reduced why because now you can see this portion which is near or has specific sizes of the tiles being stored. So, whichever tiles are much more frequent in size those are now stored close to the place where they are received. So, a person need not travel with those most frequently used sides of the tiles to far of distance.

So, these are just moving to the nearby places and which are special you can see these are the special it is written clearly special special special. So, very the special sizes are less in number so the movement is less to the far of places. So, we can very easily see here that if we use our

mental faculties if we use a little bit of creativity which each one of us has been blessed with we can very easily find solutions to these common problems.

That are observed in industry as well as sometimes these problems we observe in our life also. So, we can very easily redesign that things and here you can see by changing the location for storing the sizes of the tiles we can save the distance travelled. The distances covered were reduced from 520 to 340 meters. So, from 520 to 340 meters in the current method by changing the location of storing the tiles.

340 meters is the necessary movements unnecessary movement of 520-340 meters have been saved leading to a saving of 35%. So, we have not touched the area that we are using for storing the tiles we have only touched the location where a specific sizes of tiles will be stored. So, just by changing the location of the tiles we were able to save 35% of the unnecessary movement. So, this way we can see that.

We can change in the previous case study of a metal worker producing a box or fabricating or manufacturing a box if we change the location of the various machines we can optimize or we can reduce the unnecessary movement here in case of storing the tiles in the various locations in a ware house we can reduce the unnecessary movement by 35%. So, in this way we have a lot of applications of the string diagrams.

And some of these are it is used for recording the complex movements of materials or men it is just the conclusion for todays lecture it is used to check whether the workstation is correctly located.

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Applications

- It is used for recording the complex movements of materials or men.
- It is used to check whether the work station is correctly located.
- Used to **record irregular movements**.
- Used to **find out the most economical route**.

As in the case of the metal worker case study the facilities or the workstations were not properly located so when we located them properly we were able to reduce the unnecessary movement of the metal worker and these are used to record the irregular movement specially in case of a worker who is serving food in case of a restaurant that is one example of recording the irregular movement. Used to find the most economical route.

So, we can see that if we use the string diagram properly it can help us to redesign our layout in such a way that unnecessary movement of men and machines can be avoided. So, this is one important technique of conducting the methods study. So, with this we conclude the today's session we have started over discussion for week 6 and we will try to cover all possible techniques, graphical tools that are used for performing the method study. Thank you.