**Photogeology In Terrain Evaluation (Part-1)**
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**Lecture – 18**
**Exercise on Relief Displacement**

Hi, again welcome to our next lab that is, a relief displacement on aerial photographs. So, in this lecture we talk about the, how relief displacement is created over for a aerial photograph?

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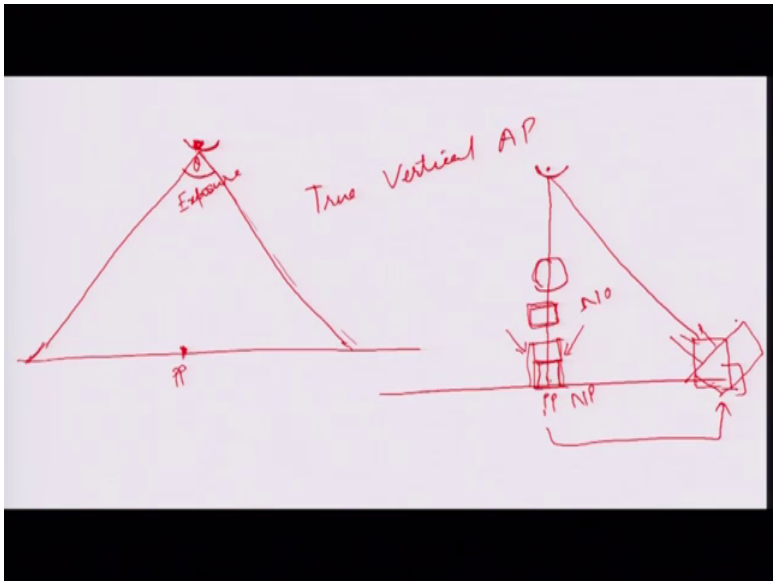


So, as we know that; when we take a photograph with a single camera it will cover an area with central projection ok. Central projection; means there is the rays will be projected from a center, that is your camera aperture and it will cover an area like this and this will be your exposure and this will be your coverage angle ok.

So, as we talk about that, the midpoint of your aerial photograph is your principal point, in a true vertical aerial photograph in a true vertical aerial photograph, the principal point and the nadir point coincides ok. What is the nadir point? Nadir point is a point below the vertically below the lens camera lens. So, when there is a true vertical aerial photograph, your principal point and your nadir point will coincide. So, this means the objects which are located near the principal point or near the nadir point will be represented in true dimensions, like there will be no distortion in their appearance.

It will look like this like you will see, you the camera is looking from a point an exposure station in the air and it will cover it is top, and this feature is shown as N square if the top of the building is of a square shape then, it will be in square shape. And whatever shape it is, it will represent the true shape of the top of the building, but suppose when there is a building which is located, away from the principal point or nadir point, this will be this will give you a difference in the appearance like, it will cover this building from this portion only and the you can see this building leaning, away from the principal point leaning away from the principal point.

But in actual position it will be like this only, but because as it is away located away from the principal point or nadir point, it will be look like this leaning outward from the principal point. So, as we look an object with our eye also.

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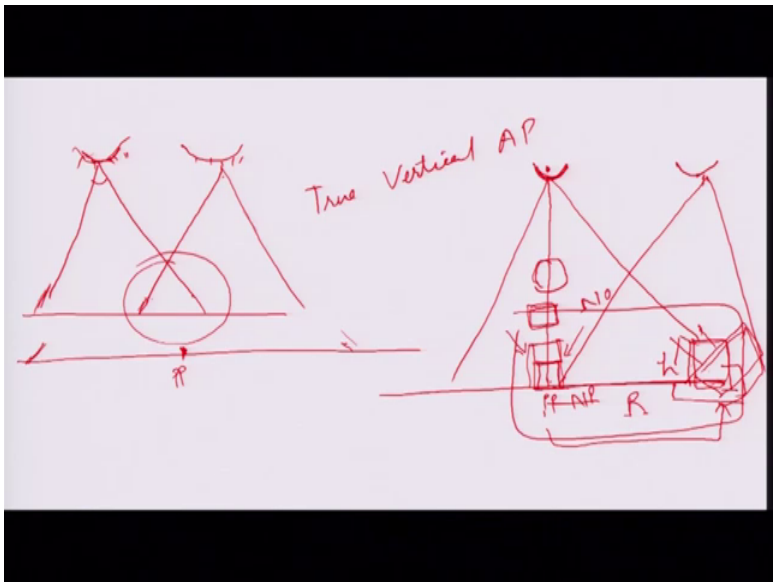


So, this is suppose we close our one eye and look over an area with a single line. So, we will have central projection in that case, but when we look without both the eyes then, it will give us an overlapping area we can view a terrain in 3D also ok.

So, that is important because we can see each and every object, if we see the objects from the top also, we can see the real dimensions of the buildings and all the objects on the surface of the earth with our both the eyes, but in case of camera there is a single lens, then there will be a central projection. If we take the same area with the two

different lenses, this will also give us true dimensions of the buildings and true positioning of the objects.

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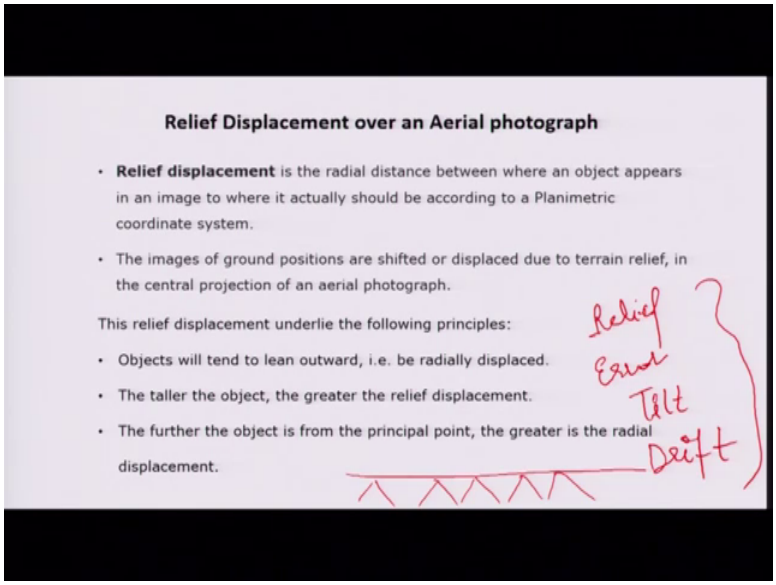


So, what is a relief displacement in terminology, it is the radial distance between where an object appears, in an image to where it actually should be according to a Planimetric coordinate system ok.

So, the images of ground positions are shifted or displaced due to terrain relief, in the central projection of an aerial photograph. So, what causes this, this can be due to presence of relief ok. This may be due to some error in photography also, some tilt, some drift and number of factors while the aircraft is moving is flying over the terrain and capturing the photographs of the area ok, as we discussed in the line (Refer Time: 06:51) lecture.

So, the relief displacement underlies the following principles like, as I talked earlier. The objects will tend to lean outward, radially displaced away from the center like this. The taller the object the great relief displacement, the further the object is from the principal point, the greater is the radial displacement ok. So, this in this case of aerial photograph, this will be your radial distance ok, this will be your height of the object. So, this will be your radial distance. So, when the radial distance is greater, there will be more relief displacement this is directly proportional to radial displacement.

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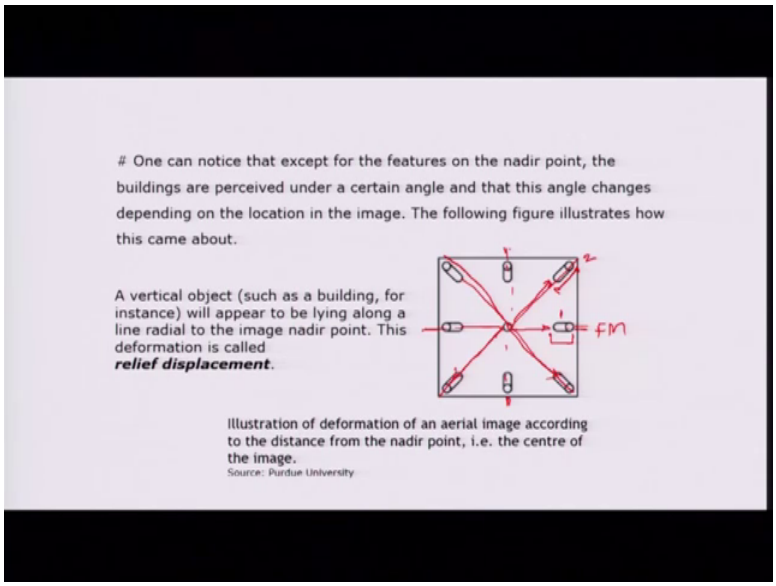


One can notice that except for the features on the nadir point, or the principal point. As you can see here, in this case of aerial photograph this will be the fidition marks, on these photographs on all the four edges, now on the midpoint of the edges. So, this will be the line joining the fidition marks will be your principal point.

So, at principal point or nadir point you will see, the true positioning and true dimensions and true image of the objects or buildings ok, buildings are perceived under a certain angle and that this angle changes depending on the location in the image. So, this building is located at the corner, away from the principal point at a greater distance, it will have more relief displacement in terms of it is length as measured on the aerial photograph, this is little closer to principal point or nadir point. So, it will have lesser relief displacement in comparison to building number 2.

So, one will have lesser relief displacement similarly this. So, all the buildings which are radially located outward and placed at a greater distance, from the principal point will have more relief displacement. This is the concept of relief displacement, hope you understand it from this figure easily. A vertical object such as building for instance will appear to be lying along or a line radial to the image nadir point, this deformation is called the relief displacement ok.

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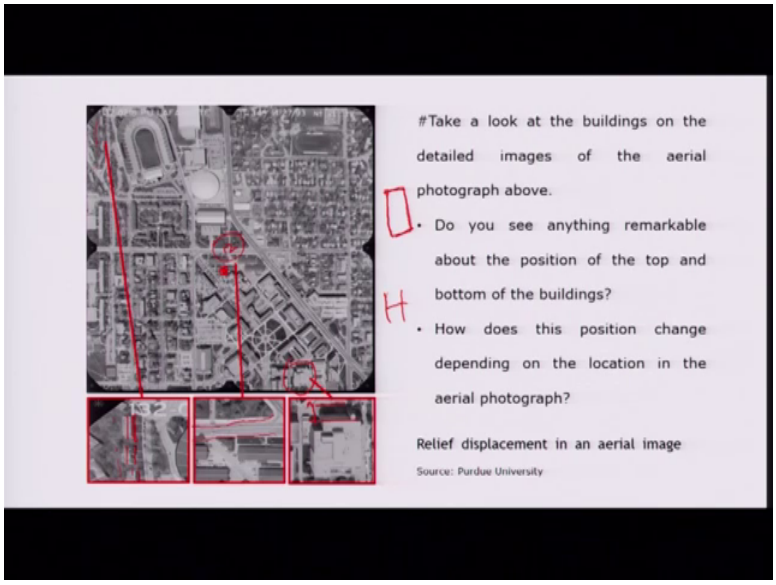


So, here this is your radial line and it shows like this, that this is the object the buildings are located position parallel to this radial line ok. So, this is the effect of relief displacement, you can take a look over this aerial photograph, area 1 this is window 2 this is window 3. Here you can see that here, the there are series of buildings these. So, these buildings are located here. So, you can see the base of the building is this, this line marks the base of the buildings this marks the top of the building base and top.

So, in case suppose if this building is located at the center. So, you will see it in a form of a rectangle, because the shape of it is terrace is rectangular, but it is located radially outward from the nadir point. So, this is the reason behind the displacement of it is terrace from it is base, base of the building similarly at displace also you can see, because there is some relief some ground relief at location window 2. So, here you can see that this road is lying going like this ok. So, it is showing some kind of displacement on the image in window 3, you can see this building very clearly this building ok.

So, you can see the base of this building here, and top of this building here ok. So, this is a another advantage over the vertical aerial photograph, we can calculate the height of the objects, by applying the relief displacement in addition to flying height that is capital H, I will explain on the next slide. So, you can see some remarkable things, about the position of the top and bottom of the buildings on this image ok, why these positions are changes are changing? It depends on the location of these buildings as I discussed earlier ok.

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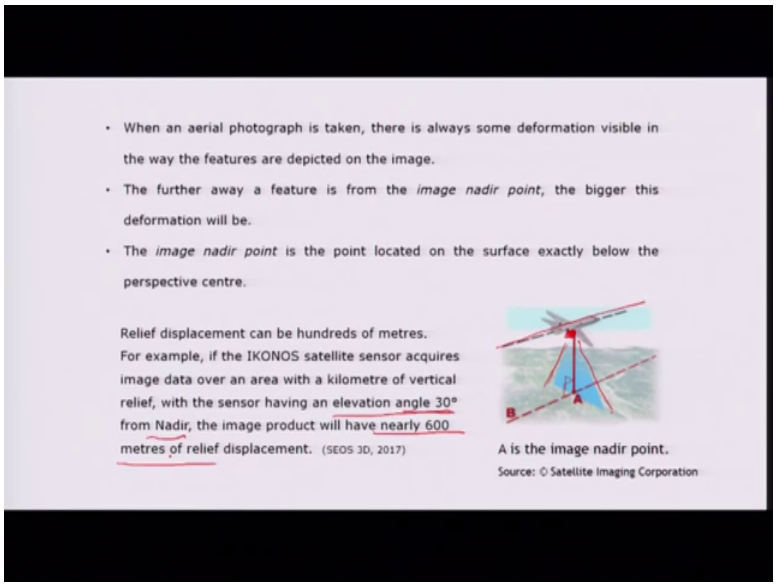


So, suppose this aircraft is flying over a terrain here ok, it is capturing this area like this ok. So, A is the image and nadir point here. So, what will happen here? When an aerial photograph is taken? There will be some deformation visible in the way; the features are depicted on the image. The further away a feature is from the image nadir point, the bigger this deformation will be, the image nadir point is the point located on the surface exactly below the perspective center, what is the perspective center? I discussed this at earlier, the perspective center or the camera lens the point vertically below the camera lens is your perspective center. It is called the nadir point.

So, the relieve displacement can be 100s of meters for example, like IKONOS satellite data, you can see the sensor requires some image data for an area with a kilometer of vertical relief ok. So, with the sensor having an elevation angle 30 degree from nadir ok so, the image product will have nearly 600 meters of relief displacement, when it is having an elevation angle of 30 degree from the nadir. So, then in that case the displacement will be nearly 600 meters on the image.

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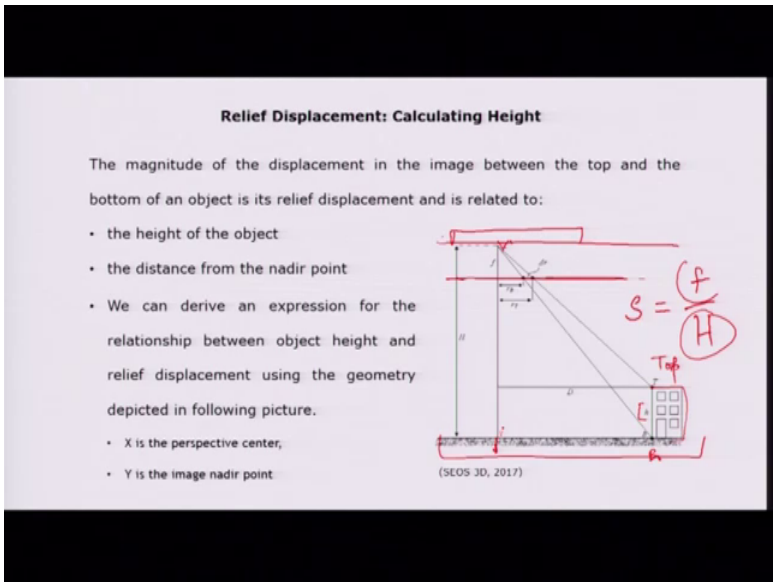


Now, how we can derive the formula for a relief displacement? From first thing you have to remember that, the relief displacement we can visualize over a single vertical photograph ok, we do not need a stereo pair for it, because it is a radial defect ok. So, we can identify it on a single vertical aerial photograph also. So, as you can see the geometry of this photograph here, this is the building this T point is representing the top this B is representing the bottom of this building and H is the height ok. So, here this is the plane of a projection, actually where the where your camera is located and this is your negative film area, where you can have the image of this ground this is the real ground ok.

You can have the image of this ground over here, this is the focal length and as you know that, the scale of a photograph is F by H F where F is focal length and H is the altitude at which there is flight ok. So, the magnitude of the displacement in the image between the top and the bottom of an object, is it is relief displacement and this is related to the height of the object, number 1, number 2 the distance from the nadir point, and we can derive the expression like suppose this x is your perspective center, and y is image in nadir point, we can derive an explanation how we can derive expression from with this geometry? I can explain in a very simple way on the next slide.

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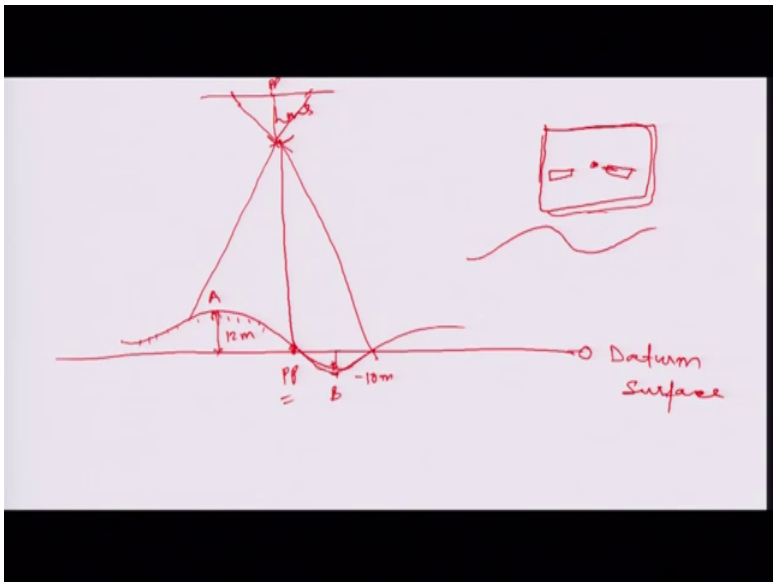


So, what happens actually when you see your ground, it will appear like this and in this ground. So, this is the relief of the ground. So, this is at this point a there is elevation of some 12 meters, suppose and at this point B there is a depression or a basin like a structure ok, you can say the minus 10 meter and because, we are considering this line as our datum surface, you can say it datum surface or datum plane, from this 0 line this is below this datum surface and this is this point is point a is above the datum surface.

So, if we take photograph of this area like this. So, suppose this is the ground and the photographic principal point is lying here ok. So, this is your lens and this is covering, these areas like this ok, similarly you can get your photograph like this. So, at some point here this will be your principal point on the photograph. So, what happen the there is a elevation change on the topography, from the centre of the photograph, we can see the point which are located at a higher elevation, it appears like they are leaning outward from the principal point, but the depressions over an area they are in the form like they are leaning towards the principal point ok.

So, this is the difference of relief, which controls the amount of the relief displacement over an area photograph so, another important thing how to derive measurement for the relief displacement in a simple way.

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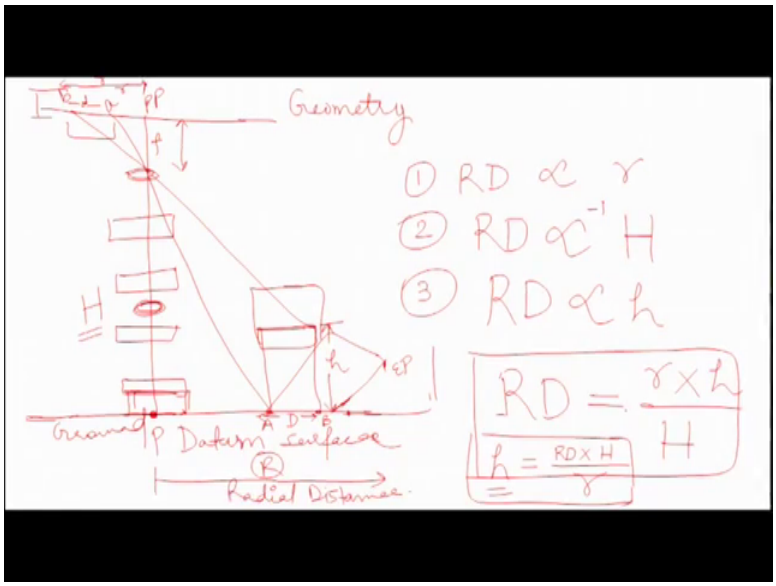


So, now after having an understanding of relief displacement, let us try to understand it in a very simple geometry. So, that you do not have any confusion, while doing your practical's. So, suppose this is your ground ok, let us draw this ground lower. So, this is your ground which is taken by the lens mounted on a camera, this is the altitude of your camera, altitude of your flying height you can say, this is your datum surface simply data and suppose this is a building over this plane.

So now you have to map this building, you have to cover you have to understand the relief displacement with the help of this object over this photograph. So, this is your ground, there will be a photographic negative ok. So, a simple geometry the rays will go like this and at one part, it will cover it is top the top of the building. So, this point on ground is this point is on ground is b. So, here these point small and this point small b. So, these two a small a b represents capital A B ok, the location of these points. So, this is your lens and this is of course, your focal length from here to here.

So, what you can do? Suppose the height of this building is H, this is the over ground ok. So, this capital D represents the coverage of this building over ground. So, this will be small d here from point a to b ok. So, this capital D is represented by the small d on the photograph, this will be your principal point on the photograph here, and the corresponding point is this on the ground. So, this is this distance actually from this here to here this is your capital R and similarly, from principal point to the last point of the

building covered over ground that is capital B here to small b, this will be your small r a small r.

So, the capital R is represented by small r over the photograph. So, this you know well that, the relief displacement varies with the height. So, first thing we know is suppose we say relief displacement as RD. So, real displacement is directly proportional to the altitude, the capital H y from if you if your lens is here. So, suppose a building is located here at the center of this photograph, or at the at the Nadir point, means the points directly below the perspective center which is your lens. So, this will be represented in a true shape, the top of this building suppose this is of rectangular shape.

So, from whatever height you will see it; this will be shown as the same shape ok, that is rectangular. So, what it means? The point the objects or the buildings locate which are located at nadir point or directly below the perspective center will have no relief displacement ok, will not be affected by the real displacement. So, what it means that? When an object or a building is located away from this point away from this point so, the relief displacement will be more. So, this building is represented over your photograph here, like this point a to b because, photograph is a 2-dimensional plane. So, you can see this building, but you not little what different manner you will see your building like this.

So, it will be covering your covering some of the area over the photograph ok. So, what it means that relief displacement is directly proportional to this distance this R capital R. So, what is this is your radial distance ok. So, what it means? That a relief displacement is directly proportional to the radial distance R between the displaced image and the principal point so, here this is directly proportional to your R. So, because we are talking in terms of the photograph, because we are talking in terms of the photograph so, we are taking here small r ok.

Number 2: So, suppose the same building they that, we are looking from this distance from this altitude and the same building we are looking from this altitude ok. What will happen? This will have more coverage over the photograph ok, this building will have more coverage over the photograph. It means that the radial distance of the end point of this building, suppose this is the end point. So, the radial distance from the principal point to the end point of this building, will increase as we move below as the altitude will

decrease. So, what it means that? a relief displacement when altitude is decreasing the relief displacement is increasing.

So, it is inversely proportional to your H and point number 3 is that, one thing the relief displacement is directly proportional to the difference in the elevation of an object H. So, this object or this building is having height H ok. So, when the height of this object or building increases so, then it will result into the greater relief displacement. So, what it means as this h is small, small h increases relief displacement will also increases, because the taller the building the larger area on the photograph it will cover, you understand here. So, we got to know from here that ray displacement is also directly proportional to your small h.

So, from this understanding what we have, now we can express our relief displacements formula as, relief displacement is equal to small r that is radial distance and h divided by capital H ok. So, from here we can also calculate the height of a building. So, relief displacement is of course, a defect on the photographs, but with the help of relief displacement we can calculate height of the buildings or height of any object, how we can replace this H from here? Like H will be equal to suppose relief displacement is capital RD into H by your R ok. So, this will be the formula for calculating height of a object ok.

So, what we got to know that, relief displacement directly proportional to radial distance of the object from the principal point, number 2 relief displacement inversely proportional to the altitude of the flight altitude of the camera lens ok, and the last one relief displacement is also directly proportional to the height of the objects. So, it will be explained on the next photographic example that is taken to explain you the calculation of the height of the object so, over the aerial photograph.

So, now we are going to move with our relief displacement exercise. So, how to do a practical to calculate the relief displacement, or the height of the objects with the help of relief displacement if you know so, this we will do with other type of photographs ok. So, as you know that, in the previous exercise you are looking over these photographs as a photograph.

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So now let us have some other kind of photograph. So, as you can see here, this is an UAV means unmanned aerial vehicle. So, this can take photographs of the ground, in the same manner a satellite or an aircraft takes ok. So, this with the help of this UAV you can also take photographs in a sequence, along a line of flight the overlapping photographs these are the wings ok.

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So, this is a model this model is known as phantom pro and here the lens is placed ok. So, this is a lens having a high magnification ok, a high power which can look over the ground and capture ground from a greater height also.

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So, example of the photographs taken by this UAV recently, these four photographs are the examples of the aerial photographs taken by this UAV ok. So, let us work with these photographs, to calculate a relief displacement or the height of a building ok. So, let us put this UAV.

So now, you can see that these are the four photographs, you can buy this UAV along a line of flight ok. So, this building is the computer center of IIT Kanpur and in front of this, you can see that this is a greenish plantation over here, and this is the parking lot and this is a ground, this is another building ok, actually we know the heights of this buildings. In case you are having some objects or some buildings, for which you need to calculate the height, you can do by the parameters, which I explained in the lecture slides, like relief displacement the altitude flight altitude and a radial distance from the principal point.

So, for this photograph what will be the principal point? As you know these are the examples of vertical photographs, because UAV fly in a parallel manner ok, without going up and down. If there is if there is no strong winds and then there will be no distortions in the images, and the you will get the planar projections of the images ok, from an the lens will work as a central projection, from where the rays will lie perpendicularly over the ground and, it will the principal point or the nadir point.

So, in this case because this is a true aerial vertical photograph. So, in this case your principal point, your nadir point and isocenter will coincide. So, as this R representing the axis 1 2 3 4 ok so, you can take the midpoint of the axis like this, draw a line is an always build like this and then. So, the intersection of this line here will give you the principal point. So, this will be the principal point. So, as you know. So, when this photo was captured, the UAV was flying like this, at an altitude.

So, it may be an altitude whatever altitude, we can set the altitude also ok. So, for this survey we have taken the altitude of 60 meter from the ground. So, this ground represents the datum surface and this the height from the ground. So, this will represent your flying altitude. So, this we know.

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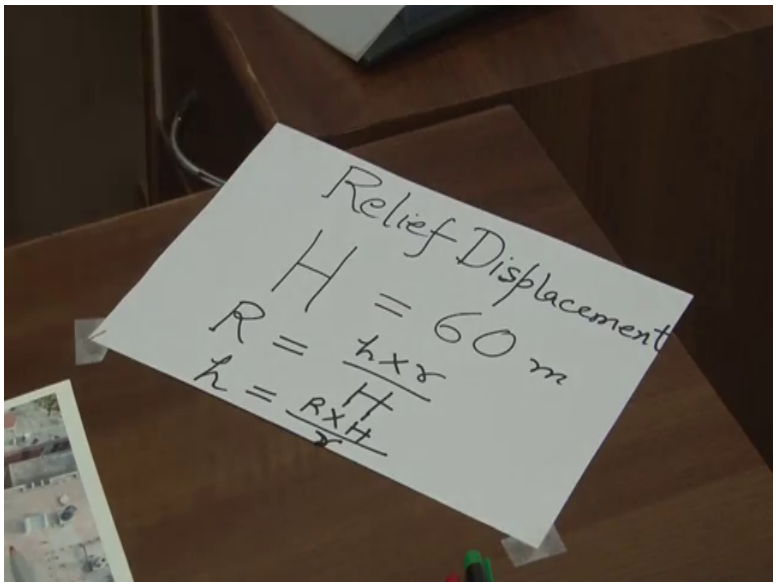


So, here if you see this so, you know the H that is flying height. This is 60 meter in this case, and you know the formula for relief displacement you see what you learn from the lecture. So, that a relief displacement directly proportional to height of the objects or anything any building, relief displacement directly proportional to radial distance from the principal point ok, and relief displacement it is inversely proportional to flying altitude flying height capital H.

So, with this information we have this formula relief displacement is equal to h into r by H. So, suppose we need to calculate h. So, suppose we have here suppose capital R your is your relief displacement and h into r by capital H ok. So, this you know so, in case which you need to calculate in case when you need to calculate, your height of the object or building. So, then simply what you will do h will be equal to R into H divided by your r let us do it. So, in case we need to calculate the height of the object or a building, what you will do? You will take your H here, and R into capital H divided by small r from here on this screen you can see.

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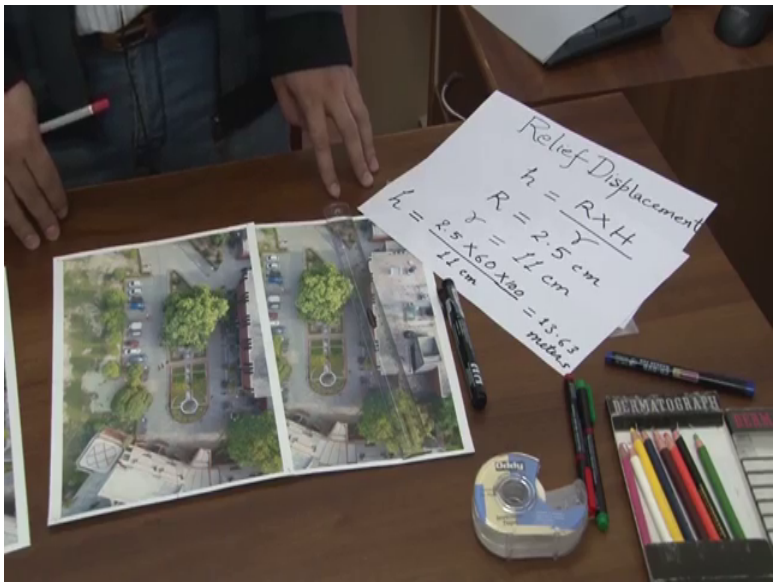


So, this will go with this capital R into H divided by r. So, here this H represents the height of the object or the height of the building, capital R represents a relief displacement H represents height of a flying altitude, and a small r represents the radial distance from the principal centre, and what is the radial distance from the principal center ?

You know this, suppose there is a building located here. And so, so distance from principal point, to the last point of the building where this building touches the ground, the top of this building touches the ground, this will be your radial distance and this D will be your relief displacement, sorry this all de photograph the of course, this is on the ground, but it is representation over the photograph, will represent the relief displacement.

So, moving ahead you know here, at this point you have your principal point. So, suppose we need to calculate the height of this building the height of this building. So, first what you will need to know. So, R H and a small r h you know capital H is 16 meter the flying altitude of the UAV, and R is your relief displacement and what it will be? It will be the distance between the bottom and top of the building. So, here we know the bottom of this building is this, and top of this building represented by this point.

So, we can measure it, we can see it by zooming your image. So, this is coming around 2.5 I can as you can see here this is coming around 2.5. So, what you know now your

relief displacement is 2.5 centimeter. So, what other thing you want to know, you know H you know R, now you want to know your small r that is the radial distance form the principal point. So, principal point is this and your radial distance up to the last up to the top of this building is.

You have to measure with the scales. So, it is coming around 11 centimeter is here, principal point to the top of this building. So, your R is small r is 11 centimeter. So, by putting these values in this formula you can get your H for the small h will be equal to 2.5 into 16 multiply it by 100 to convert it into centimeter as then divided into divided by small r. So, that is 11 centimeter ok, because this is given in meter. So, multiply it by 100 to convert into centimeter.

So, by calculating it you will get around 13.63 meters ok, 13.63 you can do these calculations by your own. So, we should get it. So, by know by looking this building you will have an idea that yes, the height of this building should be around this much ok. And so, because we see this building and we have the information about this building. So, we know that the height of this building is coming around in a true manner ok. So, this is the with the help of relief displacement, you can do such type of measurement on your photographs.

So, this topic is covered under the photogrammetric ok, on which you can do measurements on the aerial photographs, and similar in this similar manner, you can also calculate the relief displacement. Suppose you do not know the relief displacement and you are having a photograph and you know the height of any object ok.

So, you can calculate your relief displacement that, the very easy method of calculating flying a altitude is with the help of this formula, because in in many cases we are having photographs from some area, but we do not know the flying altitude. So, we can calculate by putting this information over here. So, this is the practical for relief displacement ok, in the next practical we will learn about the stereoscopic parallel lens.

Thanks.