# Rock Engineering

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**Module - 5**
**Lecture - 23**
**Classification of Rock Mass: Rock Mass Quality (Q-system) - 1**

Hello everyone. In the previous class, we discussed about the classification of rock mass; and we discussed about the first classification system, that is rock mass rating or RMR. We saw that what all are the parameters which contribute towards the calculation of RMR; how the ratings for those parameters can be assigned. Then finally, after obtaining the RMR basic value, then the adjustment for joint orientation was made in order to get the final value of RMR.

Once the RMR value is obtained, then we saw that what is the range of the RMR that can be assigned to a particular class of the rock mass. After that, we discussed various application of RMR system. So, today we will learn a new rock mass classification system, which is called as Q-system or rock mass quality. As it was there in case of RMR, in this system also we have few parameters; and we need to find out the rating corresponding to that.

We have tables in which those ratings have been given corresponding to various conditions pertaining to each of these parameters. So, let us start with this.

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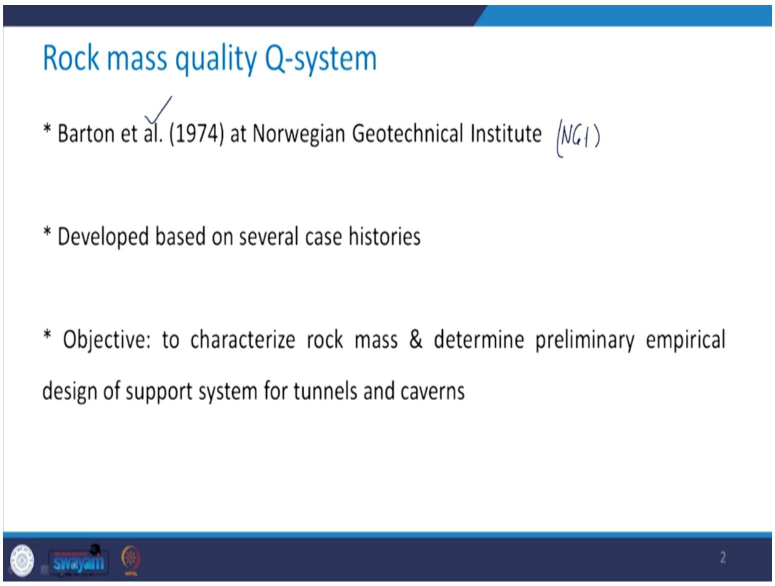

We have this rock mass quality, Q-system, which was given by Barton et al. in 1974 at Norwegian Geotechnical Institute. That is a very famous institute, NGI. This was developed based on several case histories, and the objective behind the development of this classification system was to characterize the rock mass and determine preliminary empirical design of support systems for tunnels and caverns.

This system was developed again for tunnels and caverns, as it was the case in the earlier system which is rock mass rating. In this case, again we have six parameters based upon which the index Q will be determined.

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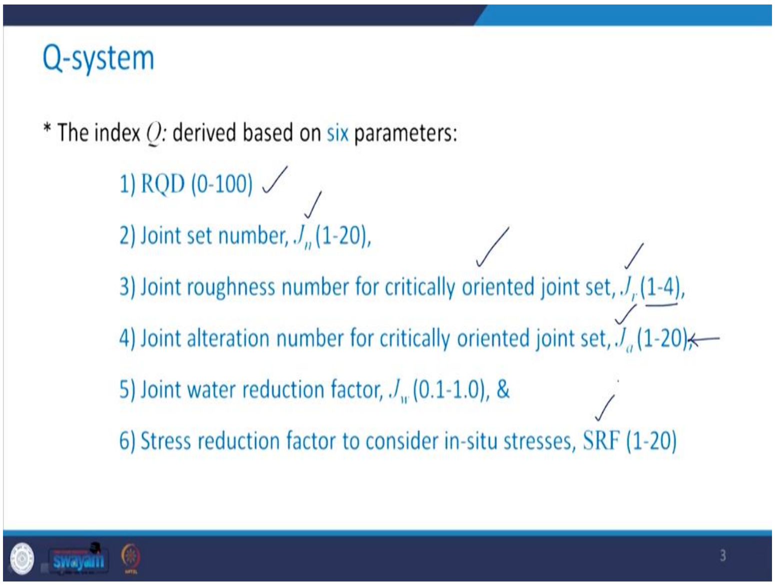


The first parameter is RQD, rock quality designation; and the rating of this can vary between 0 to 100. The second one is joint set number, $J_n$, for which the range of the rating is from 1 to 20. Third one is joint roughness number. Here, we have to take this for critically oriented joint set. Because, in a rock mass, you have seen that you can have more than one joint set.

So, the joint set which is critically oriented with respect to the structure; the roughness should be taken corresponding to that joint set. So, therefore, it is the critically oriented joint set and the roughness, $J_r$, which can take the rating between 1 and 4. The fourth parameter is joint alteration number. Again, this is to be taken for critically oriented joint set. This is denoted by $J_a$; and it can vary between 1 to 20.

The fifth one, which is because of the groundwater condition; and is called as joint water reduction factor, $J_w$. And the rating of this parameter can vary from 0.1 to 1. And finally, the last one is stress reduction factor to consider the in-situ stresses. This is called in short as SRF; and it can vary between 1 to 20. We have seen that in case of RMR, the maximum rating which was assigned was 100. However, in this case, you can see that the value or the index Q can take the value more than 100 also.

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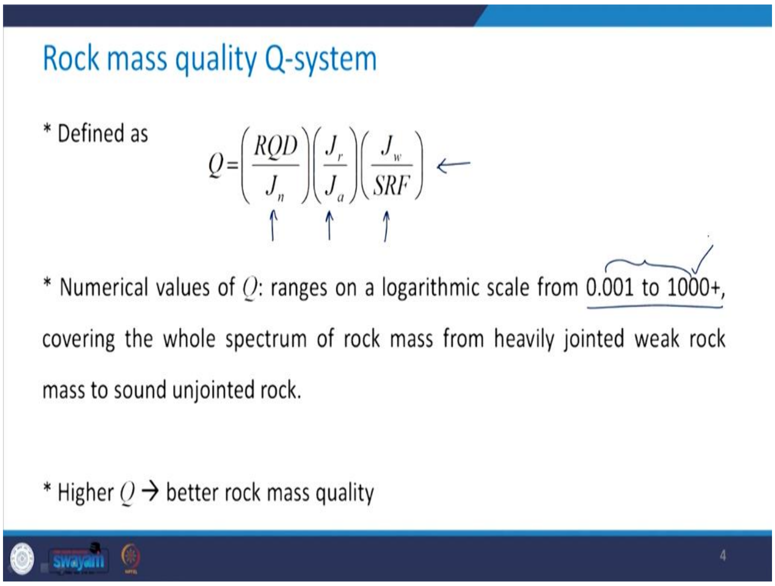


This index Q is defined by this expression,

$$Q=\left(\frac{RQD}{J_n}\right)\left(\frac{J_r}{J_a}\right)\left(\frac{J_w}{SRF}\right)$$

with the help of these 6 parameters. So, basically there are 3 quotients. The first one is RQD upon $J_n$. Second one is $J_r$ upon $J_a$. And the third one is $J_w$ upon SRF. So, we go to the field; we have the field observation; then corresponding to each of these parameters, the ratings are going to be assigned. Those ratings will be then substituted in this expression in order to get this Q-index.

So, the numerical values of Q, they range on a logarithmic scale from 0.001 to 1000 plus. So, as I mentioned that as against RMR, this Q-index can take more than 100 as its value. Now, this whole range, it covers the complete spectrum of rock mass starting from heavily jointed weak rock mass to sound unjointed rock. Because the range is huge; and therefore, it covers the whole spectrum of the rock mass. Now, higher is the value of this Q-index, this represents better quality of the rock mass.

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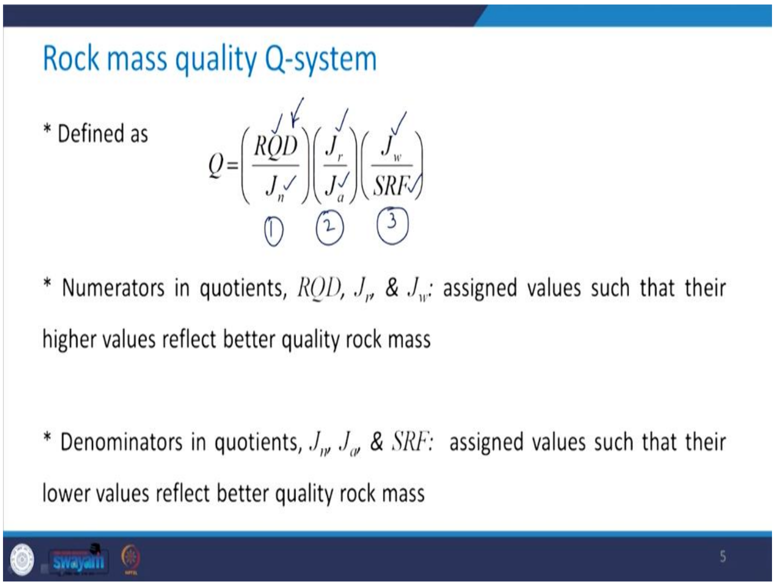


See here, in this expression, we have 3 quotients: first, second and the third one. So, whatever are the parameters which are there in the numerator in all these quotients; RQD, $J_r$ and $J_w$; these take the values such that their higher values reflect better quality of the rock mass. That means, if these have larger values; so, you can see that these are in numerator; so, higher values will give me the higher value of Q.

And we have seen that if this Q-index is higher, it represents better quality of rock mass. But this Q is also inversely proportional; or there exists a inverse relation with the denominators of these quotients like $J_n$, $J_a$ and SRF. So, these 3 parameters and their values are such that their low values reflect better quality of rock mass. So, the moment these quotients, they are higher, it will give us the representation for the better rock mass.

So, this is an important point. All these 3 numerator, RQD, $J_r$ and $J_w$; their higher values reflect better quality. However, all the denominators $J_n$, $J_a$ and SRF; their lower values reflect better quality of rock mass. Coming to the first parameters and how the rating is assigned to that. The first parameter is RQD.

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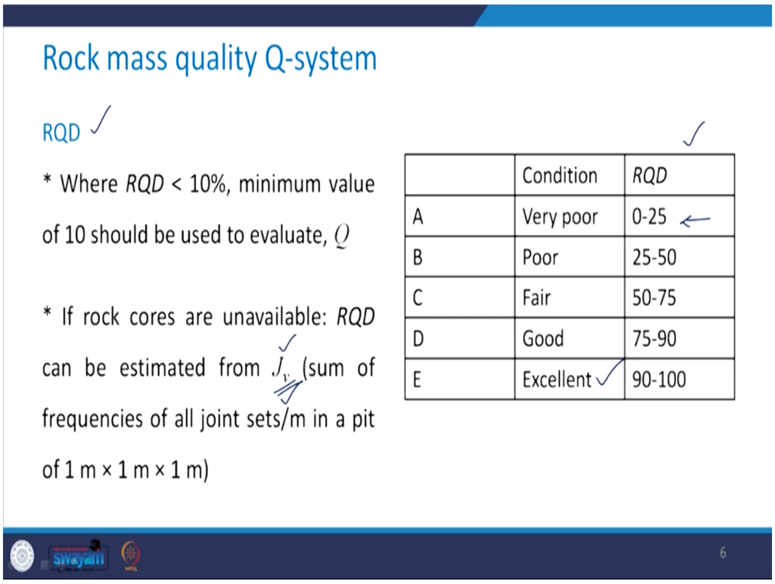


So, here, this table gives us the idea about the range of the RQD and the condition associated with that. So, you can see here that, if RQD is varying between 0 to 25, the condition of the rock mass is called as very poor. And if it is varying between 90 to 100, the rock mass condition is considered to be excellent. And somewhere in between, you have poor, fair and good quality of rock mass.

So, when the RQD is less than 10%, the minimum value of 10 should be taken in the expression of Q. So, say that, if RQD = 5; so, we will not take RQD = 5, but RQD = 10 when we calculate this index Q. Now, if the rock cores are unavailable, then RQD can be estimated from this $J_v$, which is sum of the frequency of all joint sets per metre in a pit of $1 m^3$. This is same as the volumetric joint count that we discussed in some of the earlier lectures.

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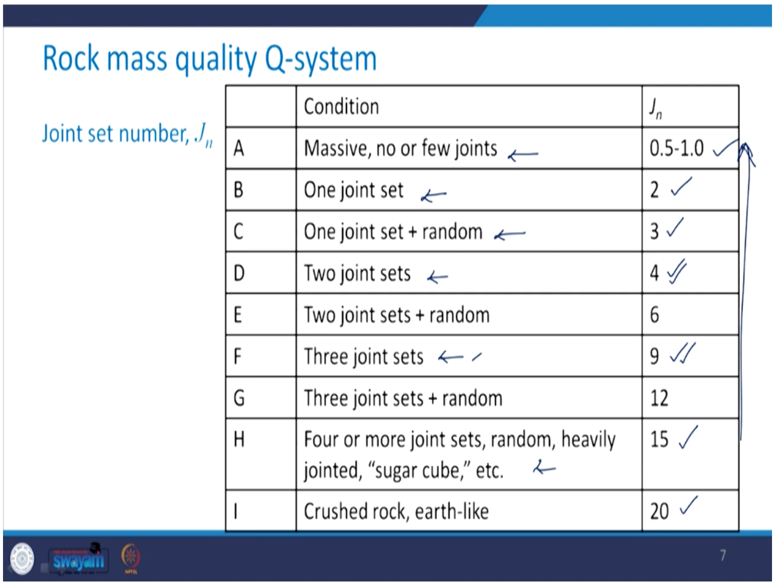

Whatever is the value of RQD, the same value will be there for its rating. So, directly the value of RQD is to be substituted in the expression while calculating the index Q. The second parameter is joint set number. And this table gives us the idea about the rating which should be assigned to this parameter $J_n$ with respect to its condition. So, if this has no or very few joints or it is massive, then $J_n$ varies from 0.5 to 1.0.

If the rock mass has only one joint set, the rating to $J_n$ which is assigned is 2. If it has one joint set plus some random joints, then the rating is 3; for 2 joints sets, it is 4; for 3 joint sets, it is 9. So, you can see that roughly; I can say that the rating of $J_n$ is roughly equal to the square of the number of joint sets. So, here it was 2, so this rating was 4; here it is 3, so this is 9. Similarly, for 4 or more joint sets; random, heavily jointed or sugar cube, etcetera; you have a rating of 15.

And last category is for crushed rock or earth-like material; for that, the rating is assigned as 20. So, as I mentioned to you that this joint set number is in the denominator of the first quotient; and I mentioned to you that the lower value will represent the better quality of the rock mass. So, that is how this table also shows, that when this rating for $J_n$, it reduces in this direction, the quality of the rock mass is getting better.

This joint set number represents the number of joint sets. And we have already discussed these in detail when we were discussing about the factors influencing the discontinuities; that the joint sets are influenced by foliations, schistocity, slaty cleavages or beddings and other geological structures.

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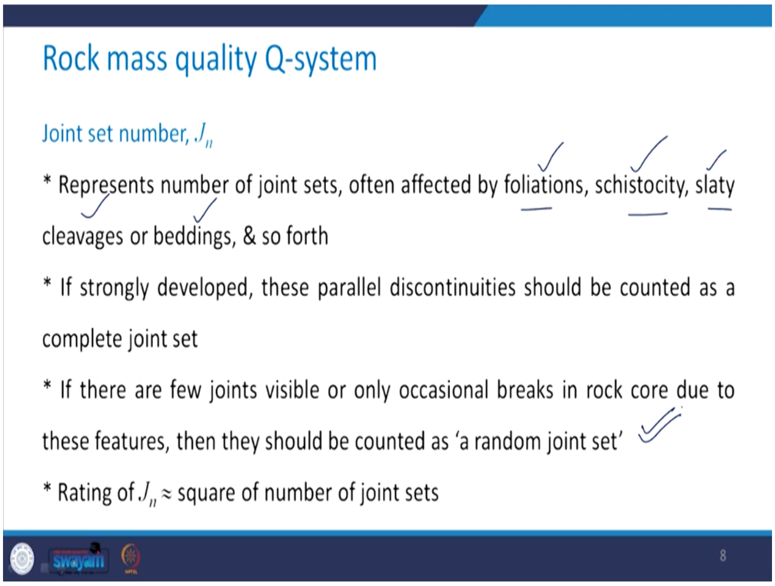


Now, if the joints are strongly developed, these parallel discontinuities should be considered as a complete joint set. But if there are few joints which are visible or only there is occasional break in the rock core due to some of these features, then they should be counted as a random joint set. So, in the previous table wherever you have seen that 2 joint sets plus random; so, the definition of a random joint set is given here, that if there are few joints or occasional breaks, they should be considered as the random joints. Rating of $J_n$ is approximately equal to square of the number of joint sets.

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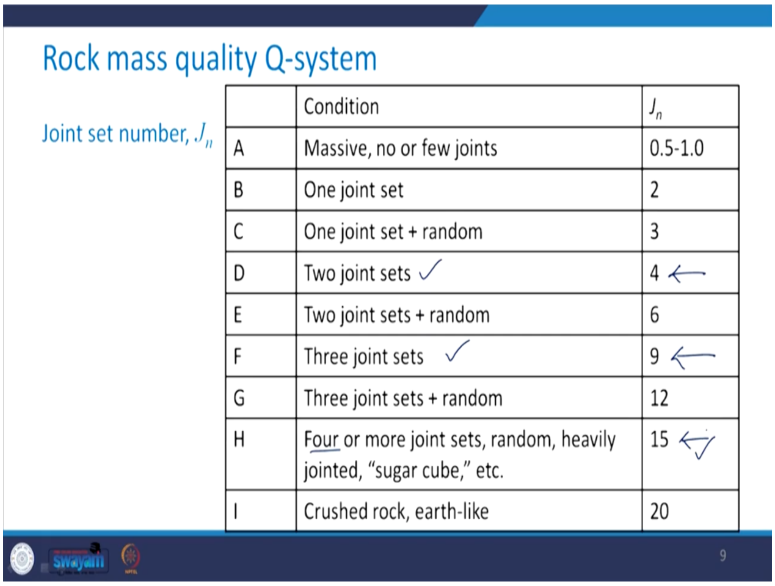


| | Condition | $J_n$ |
|---|---|---|
| A | Massive, no or few joints | 0.5-1.0 |
| B | One joint set | 2 |
| C | One joint set + random | 3 |
| D | Two joint sets | 4 |
| E | Two joint sets + random | 6 |
| F | Three joint sets | 9 |
| G | Three joint sets + random | 12 |
| H | Four or more joint sets, random, heavily jointed, "sugar cube," etc. | 15 |
| I | Crushed rock, earth-like | 20 |

So, once again look at this table; 2 joint sets, 4 rating; 3 joint sets, 9 rating. And if you have 4 joint sets, so, about; it should be; if we go strictly by that definition, it should be 16; but since it is approximately equal to, so the rating is assigned as 15; for 4 or more joint sets, random, heavily jointed or sugar cube kind of the rock mass.

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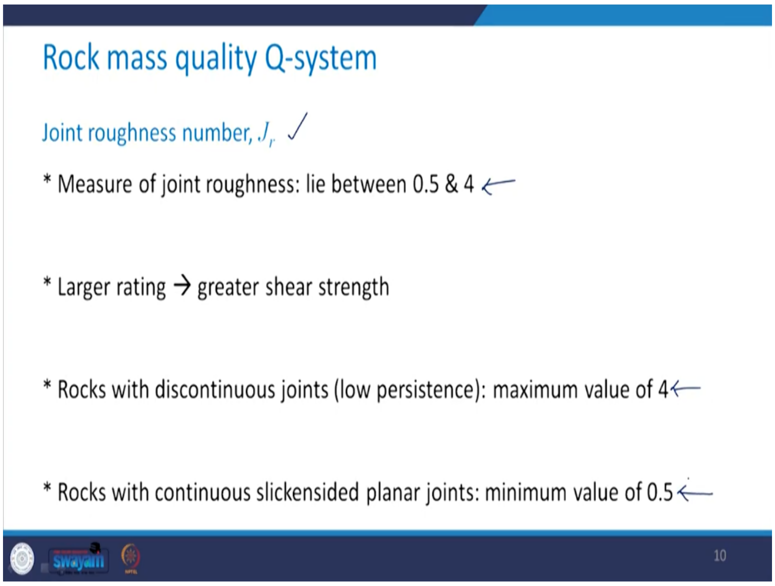


Coming to the next category or the next parameter which is the joint roughness number. This is represented as $J_r$. The measure of joint roughness, it lies between 0.5 and 4. As the rating of this $J_r$ is larger, this will represent the greater shear strength, because this parameter is in the numerator of the second quotient in the expression of Q-index. Rocks with discontinuous joints which have low persistence; you will have the maximum value of 4. And when you have rocks with continuous slicken sided planar joints, a minimum value of 0.5 is adopted.

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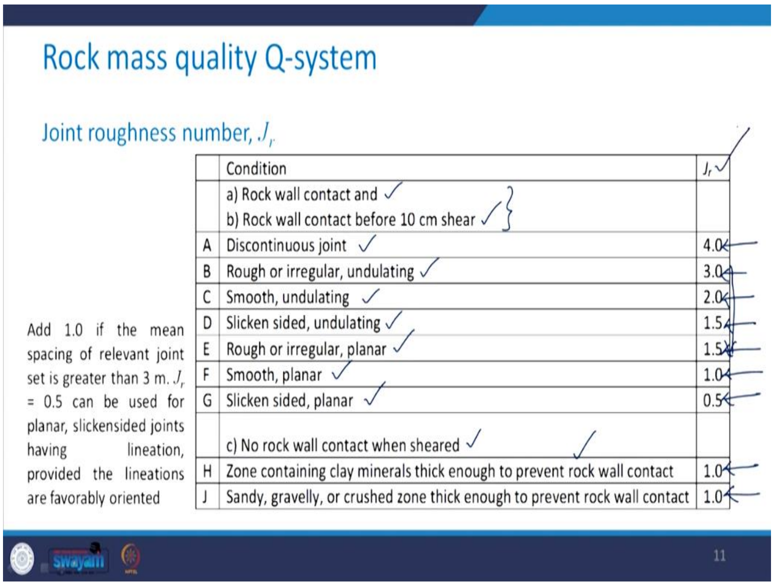


Based upon the condition of the joint, this rating is assigned as per this table. So, here you can see that there are 3 conditions. The first one is, rock wall contact; and rock wall contact before 10cm of shear. And then the last one is, no rock wall contact when sheared. So, for these first 2 conditions, in case if you have the discontinuous joint, rating of 4 should be assigned.

And as the roughness of the joint keeps reducing, the rating also will keep reducing in this direction. You can have a look, that here we have rough or irregular and undulating joint with the rating of 3; then smooth and undulating; then slicken sided and undulating; rough or irregular and planar; smooth, planar; and slicken sided, planar; and rating will keep on reducing like 2; 1.5; and for this one, it is 1.5 only; here it is 1; and 0.5 for slicken sided, planar kind of joint faults.

Now, when you have no rock wall contact; when it is sheared; so, zone which contains clay minerals thick enough to prevent rock wall contact, they are assigned the rating of 1. If you have sandy, gravelly or crushed zone, thick enough to prevent rock wall contact, then also you have a rating of 1.0, which should be assigned to this parameter $J_r$.

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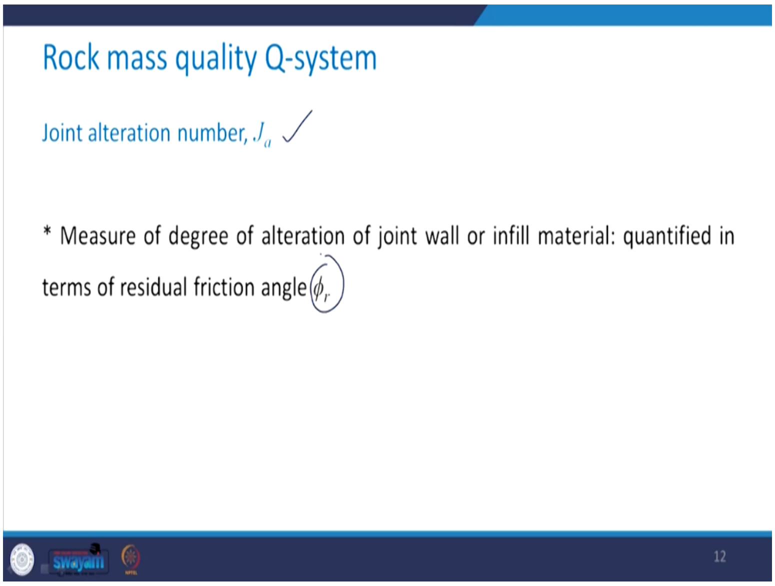


The next parameter is joint alteration number which is represented as $J_a$. This is the measure of degree of alteration of joint wall or infill material; and is quantified in terms of residual friction angle phi r ($\phi_r$). Let us see that how the rating for $J_a$ should be assigned based upon the condition of the joint as far as its alteration is concerned. So, the first category or first condition of the rock wall includes; rock wall, they are in contact with each other and there is no mineral filling and only coating may be there;

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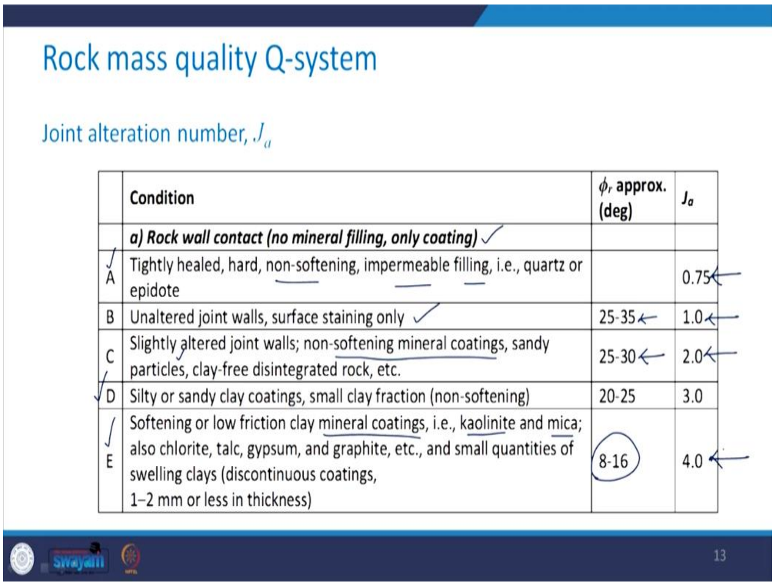

Rock mass quality Q-system

Joint alteration number, $J_a$

| | Condition | $\phi_r$ approx. (deg) | $J_a$ |
|---|---|---|---|
| | *a) Rock wall contact (no mineral filling, only coating)* | | |
| A | Tightly healed, hard, non-softening, impermeable filling, i.e., quartz or epidote | | 0.75 |
| B | Unaltered joint walls, surface staining only | 25-35 | 1.0 |
| C | Slightly altered joint walls; non-softening mineral coatings, sandy particles, clay-free disintegrated rock, etc. | 25-30 | 2.0 |
| D | Silty or sandy clay coatings, small clay fraction (non-softening) | 20-25 | 3.0 |
| E | Softening or low friction clay mineral coatings, i.e., kaolinite and mica; also chlorite, talc, gypsum, and graphite, etc., and small quantities of swelling clays (discontinuous coatings, 1–2 mm or less in thickness) | 8-16 | 4.0 |



So, this is the situation. And if you have a class A which is tightly healed, hard, non-softening, impermeable filling, that is quartz or epidote, then this $J_a$ is assigned as 0.75. For unaltered joint walls having surface staining only, this residual friction angle is of the order of 25 to 35; and the rating which is assigned to joint alteration number is 1. Then, coming to the class C which has slightly altered joint walls, non-softening mineral coating, sandy particles and clay-free disintegrated rock, etcetera; the range of this friction angle is from 25 to 30 degree; and the rating is 2.

Likewise, you have class D and class E. For class E, it is softening or low friction clay mineral coating, which can be kaolinite and mica; also chlorite, talc, gypsum and graphite etc. So, for this, you see that the phi r ($\phi_r$) value is so low, which is of the ordered of 8 to 16. And the rating which is assigned is 4. So, as explained earlier, larger the rating of joint alteration number, poor quality of rock mass it represents. Coming to the next category of the condition;

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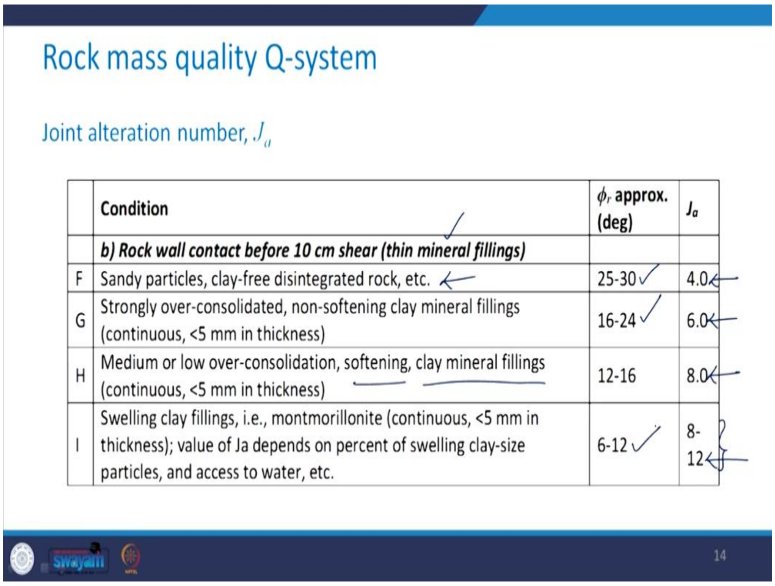

Rock mass quality Q-system

Joint alteration number, $J_a$

| | Condition | $\phi_r$ approx. (deg) | $J_a$ |
|---|---|---|---|
| | ***b) Rock wall contact before 10 cm shear (thin mineral fillings)*** | | |
| F | Sandy particles, clay-free disintegrated rock, etc. | 25-30 | 4.0 |
| G | Strongly over-consolidated, non-softening clay mineral fillings (continuous, <5 mm in thickness) | 16-24 | 6.0 |
| H | Medium or low over-consolidation, softening, clay mineral fillings (continuous, <5 mm in thickness) | 12-16 | 8.0 |
| I | Swelling clay fillings, i.e., montmorillonite (continuous, <5 mm in thickness); value of Ja depends on percent of swelling clay-size particles, and access to water, etc. | 6-12 | 8-12 |



That is when rock wall contact is there before 10cm of shear; and this will have thin mineral fillings. So, in that case, if you have sandy particles, clay-free disintegrated rock, etcetera; then this phi r varies between 25 to 30º; and the rating which is assigned to $J_a$ is 4. In case of the strongly over-consolidated, non-softening clay mineral fillings; and this should be continuous with a thickness less than 5 millimetre; then the $\phi$ value is 16 to 24; and the rating is 6.

Similarly, if you have medium or low over-consolidation, softening clay mineral filling, then the rating is even higher. And the last one in this is swelling clay fillings. And in that case, you can see that the rating goes as high as 12, with $\phi_r$ ranging between 6 to 12 degrees.

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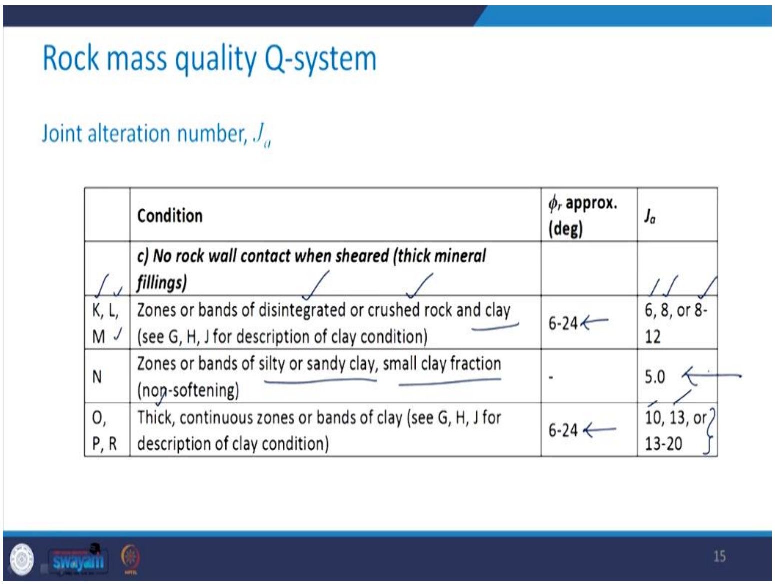

Rock mass quality Q-system

Joint alteration number, $J_a$

| | Condition | $\phi_r$ approx. (deg) | $J_a$ |
|---|---|---|---|
| | ***c) No rock wall contact when sheared (thick mineral fillings)*** | | |
| K, L, M | Zones or bands of disintegrated or crushed rock and clay (see G, H, J for description of clay condition) | 6-24 | 6, 8, or 8-12 |
| N | Zones or bands of silty or sandy clay, small clay fraction (non-softening) | - | 5.0 |
| O, P, R | Thick, continuous zones or bands of clay (see G, H, J for description of clay condition) | 6-24 | 10, 13, or 13-20 |

Coming to the next and the last condition of the joint; that is when no rock wall contact is there when it is sheared; and this also represent the situation with thick mineral fillings. So, in that case, you have the 3 classes: K, L and M. So, this will have zones or bands of disintegrated or crushed rock and clay. Phi (ϕ), you can see that it varies between 6 and 24; and J can be taken as 6, 8 or from 8 to 12.

Next category is zones or bands of silty or sandy clay, small clay fraction; which is non-softening obviously because it is the clay. So, phi will not be that significant; and the rating which is assigned is 5. Last one is thick, continuous zones or bands of clays. So, in that case, it is 6 to 24$^{o}$; and the rating which is assigned is 10, 13 or ranging between 13 to 20; corresponding to what is the condition that you have. If you have thick, it will be 10; continuous zones, you will have 13; and if you have bands of clay, it will be between 13 to 20.

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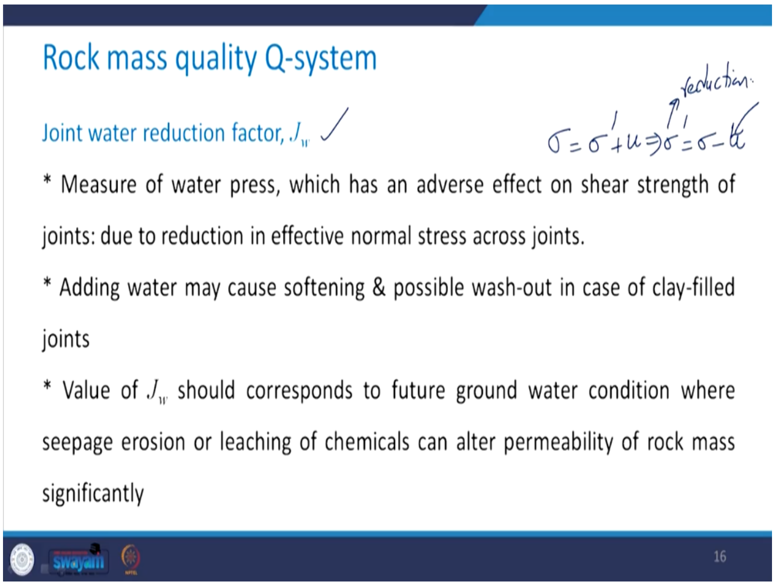


Next factor is joint water reduction factor which is represented as $J_w$. This gives the idea about the measure of water pressure, which has an adverse effect on the shear strength of joints. Why this will happen? We have discussed that we know that, the total stress is equal to effective stress plus the pore water pressure. Or from here, we can obtain, effective stress is total stress minus the pore water pressure.

So, when there is a presence of water, this pore water pressure will be large; and therefore, this will reduce this effective stress. And because of the reduction in the effective normal stress across the joint, you are going to get the low value of shear strength. So, adding the water may cause softening and possible washout in case you have clay-filled joints. Value of $J_w$ should corresponds to the future groundwater condition, where seepage erosion or leaching of chemicals can alter the permeability of rock mass significantly.

So, let us say that you have conducted the field study today. And it is a summer season and say it is dry. But then, you have seen the condition that lot of joints are there; they may be open; they may be closed. And in case of the closed joints, some infilling material will be there. So, in rainy season, water can seep through this and the clay which are there in, as a infilling material, it can be washed out. So, we need to keep all these future groundwater condition in mind when we assign the rating to this factor which is joint water reduction factor.

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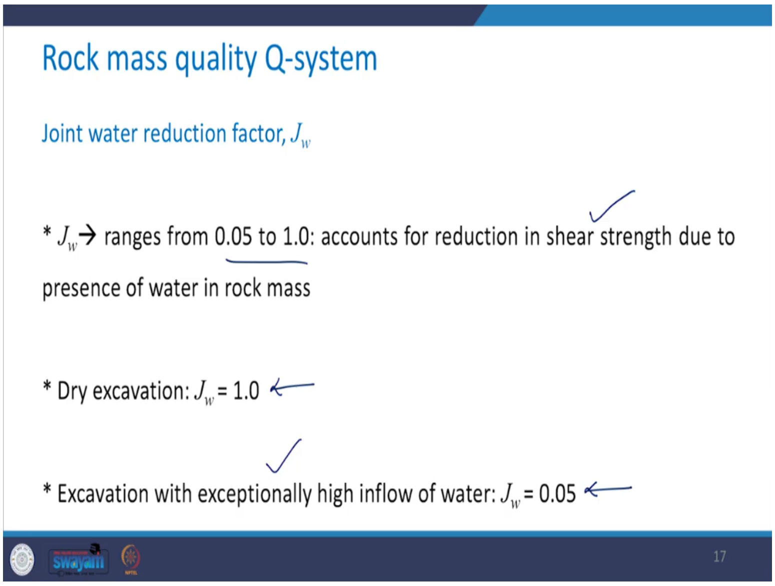


This ranges from 0.5 to 1.0; and it accounts for the reduction in shear strength due to the presence of water in rock mass. As far as dry excavation is concerned, $J_w$ is assigned a value of 1.0. And for the excavation with exceptionally high inflow of water, a low value as 0.05 is assigned to $J_w$.

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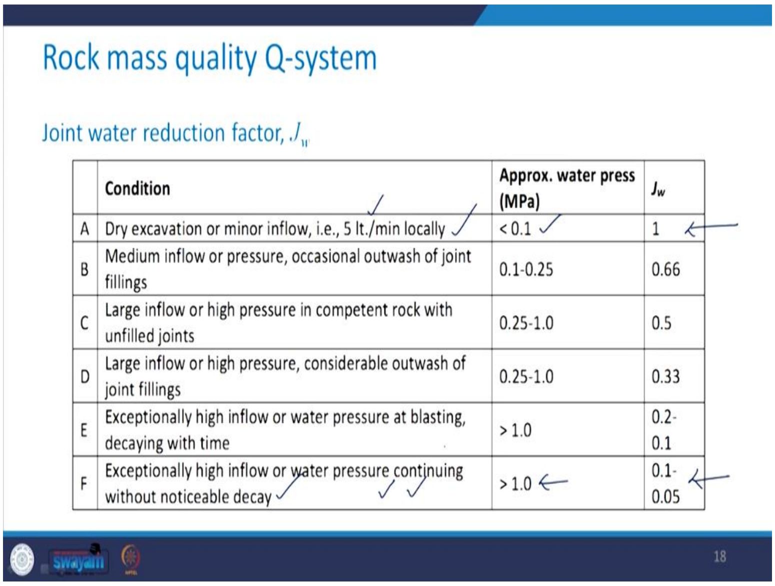

## Rock mass quality Q-system

### Joint water reduction factor, $J_w$

| | Condition | Approx. water press (MPa) | $J_w$ |
|---|---|---|---|
| A | Dry excavation or minor inflow, i.e., 5 lt./min locally | < 0.1 | 1 |
| B | Medium inflow or pressure, occasional outwash of joint fillings | 0.1-0.25 | 0.66 |
| C | Large inflow or high pressure in competent rock with unfilled joints | 0.25-1.0 | 0.5 |
| D | Large inflow or high pressure, considerable outwash of joint fillings | 0.25-1.0 | 0.33 |
| E | Exceptionally high inflow or water pressure at blasting, decaying with time | > 1.0 | 0.2-0.1 |
| F | Exceptionally high inflow or water pressure continuing without noticeable decay | > 1.0 | 0.1-0.05 |



This table gives us the idea about the ratings which should be assigned based upon the approximate water pressure and the condition of the excavation. So, in case if you have dry excavation or minor inflow; that means 5 litres per minute locally; then the water pressure is going to be less than 0.1 MPa; and the rating which is assigned is 1. Likewise, as the flow increases, then the rating is reduced.

So, you can see the last category which is like, when you have exceptionally high inflow or water pressure continuing without noticeable decay, then the approximate water pressure will be more than 1 MPa; and the rating is assigned between 0.1 to 0.05. So, these are the 2 extreme cases. One is the dry excavation; second one is exceptionally high inflow of water; and in between, you have 4 other categories; and you can see how the rating to this parameter $J_w$ will be assigned.

So, as the inflow of the water is more, you will have lesser rating assigned to this factor $J_w$. C to F, in the previous table; they are the crude estimate; and they have to be increased if proper drainage measures are installed. Special problems formed by ice formation are not considered while assigning the ratings to this parameter $J_w$. For a water carrying tunnel excavated through a dry rock mass, we need to consider the class B for this J w rating.

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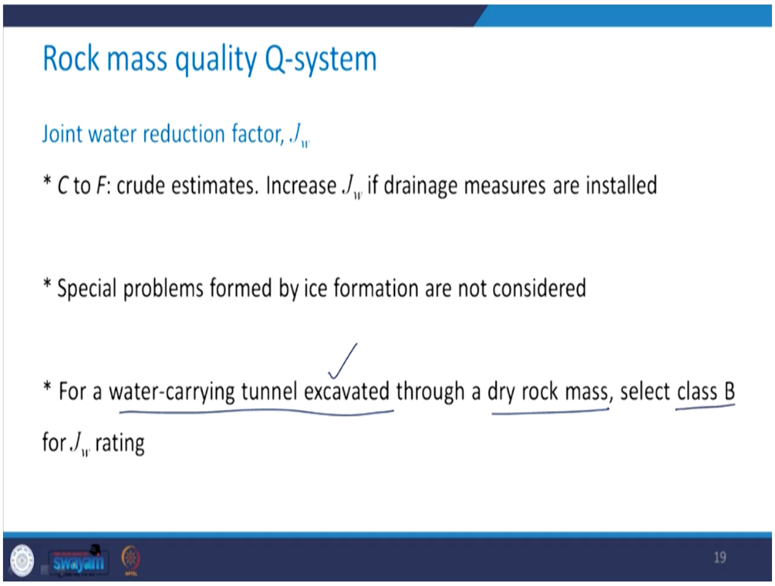


This is the point which should be noted, because this category was not mentioned in the table. So, in case if you have such type of situation; although the rock mass is dry, but the tunnel which is excavated through it, it is carrying the water; so, we need to pick the rating corresponding to class B.

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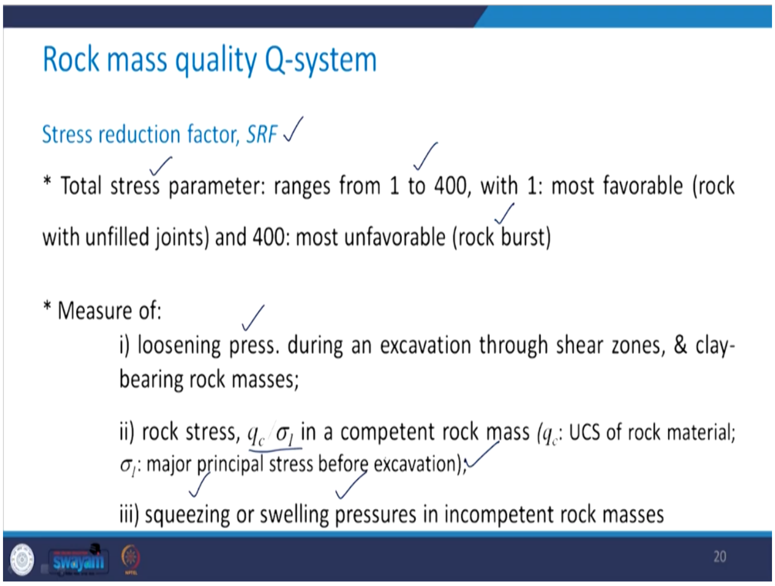


The last factor which contributes towards the calculation of the Q-index is stress reduction factor, which in short is called as SRF. This is the total stress parameter; and it ranges from 1 to 400, with 1 being the most favourable condition and 400 being the most unfavourable condition. When I say most favourable condition, that corresponds to rock with unfilled joints; and for most unfavourable condition corresponds to the phenomena called rock burst.

This SRF is a measure of 3 things. The first one is: It is the measure of loosening pressure, during an excavation through the shear zones and clay bearing rock masses. Second category includes the rock stress, $q_c$ upon $\sigma_1$, in a competent rock mass; where $q_c$ is the UCS of the rock material or the intact rock; and $\sigma_1$ is the major principal stress which is before the excavation. Then the third quantity is squeezing or swelling pressures in incompetent rock masses. So, all these 3 quantities, they are represented by this factor SRF.

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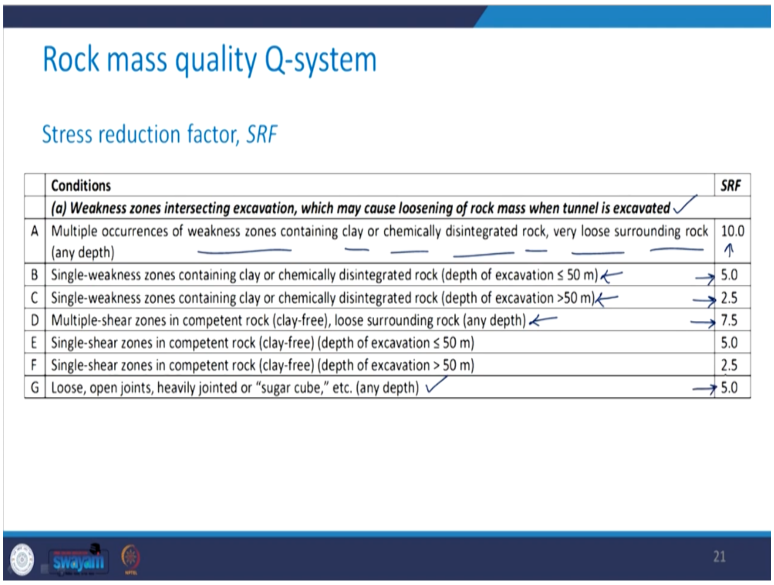


| | Conditions | SRF |
|---|---|---|
| | ***(a) Weakness zones intersecting excavation, which may cause loosening of rock mass when tunnel is excavated*** | |
| A | Multiple occurrences of weakness zones containing clay or chemically disintegrated rock, very loose surrounding rock (any depth) | 10.0 |
| B | Single-weakness zones containing clay or chemically disintegrated rock (depth of excavation ≤ 50 m) | 5.0 |
| C | Single-weakness zones containing clay or chemically disintegrated rock (depth of excavation >50 m) | 2.5 |
| D | Multiple-shear zones in competent rock (clay-free), loose surrounding rock (any depth) | 7.5 |
| E | Single-shear zones in competent rock (clay-free) (depth of excavation ≤ 50 m) | 5.0 |
| F | Single-shear zones in competent rock (clay-free) (depth of excavation > 50 m) | 2.5 |
| G | Loose, open joints, heavily jointed or "sugar cube," etc. (any depth) | 5.0 |

How? We will see when we assign the rating to SRF as per this table. So, the first one is the weakness zones intersecting excavation, which may cause loosening of rock mass when the tunnel is excavated. So, that is the first category. So, in this one, we can have the condition of multiple occurrences of weakness zones containing clay or chemically disintegrated rock, very loose surrounding rock at any depth; and then the rating is assigned as 10.

If you have single weakness zones containing clay or chemically disintegrated rock with depth of excavation less than or equal to 50 metre, a rating of 5 is assigned. And if the depth of excavation is more than 50 metre, rating of 2.5 is assigned. When you have multiple shear zones in the competent rock or you have loose surrounding rock at any depth; see, the rating of 7.5. And likewise, if you have loose open joints, heavily jointed or sugar cube, etcetera, at any depth; then you will have rating of 5. Coming to the next condition.

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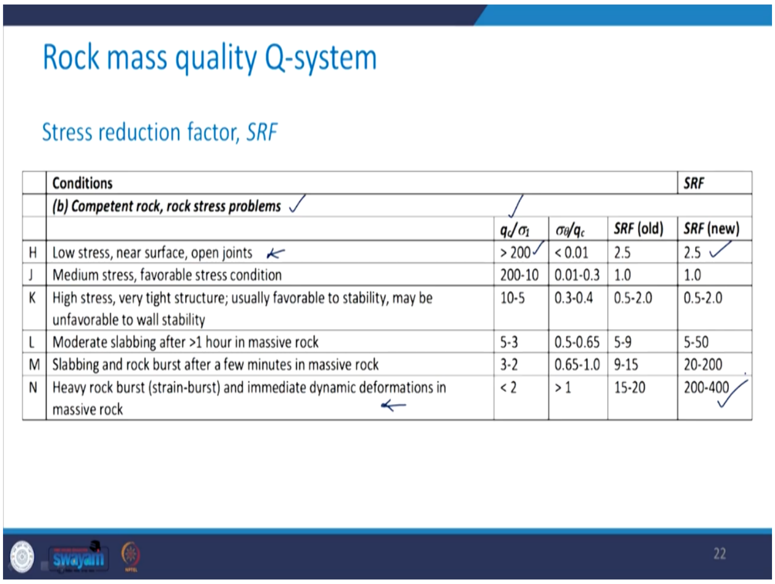


| | Conditions | | | | SRF |
|---|---|---|---|---|---|
| | *(b) Competent rock, rock stress problems* | | | | |
| | | $q_c/\sigma_1$ | $\sigma_\theta/q_c$ | *SRF* (old) | *SRF* (new) |
| H | Low stress, near surface, open joints | > 200 | < 0.01 | 2.5 | 2.5 |
| J | Medium stress, favorable stress condition | 200-10 | 0.01-0.3 | 1.0 | 1.0 |
| K | High stress, very tight structure; usually favorable to stability, may be unfavorable to wall stability | 10-5 | 0.3-0.4 | 0.5-2.0 | 0.5-2.0 |
| L | Moderate slabbing after >1 hour in massive rock | 5-3 | 0.5-0.65 | 5-9 | 5-50 |
| M | Slabbing and rock burst after a few minutes in massive rock | 3-2 | 0.65-1.0 | 9-15 | 20-200 |
| N | Heavy rock burst (strain-burst) and immediate dynamic deformations in massive rock | < 2 | > 1 | 15-20 | 200-400 |

That is where the rock stress problems are there in case of the competent rocks. So, when you have low stress and it is near the surface with open joints, then the rating is 2.5. And see this ratio, $q_c/\sigma_1$ is more than 200 in this case. And when you go further, that is in the worst case, when you have heavy rock burst or strain burst; so, basically rock burst is a sudden release of the energy; and immediate dynamic deformations in the massive rock mass; then see, the SRF goes from 200 to 400.

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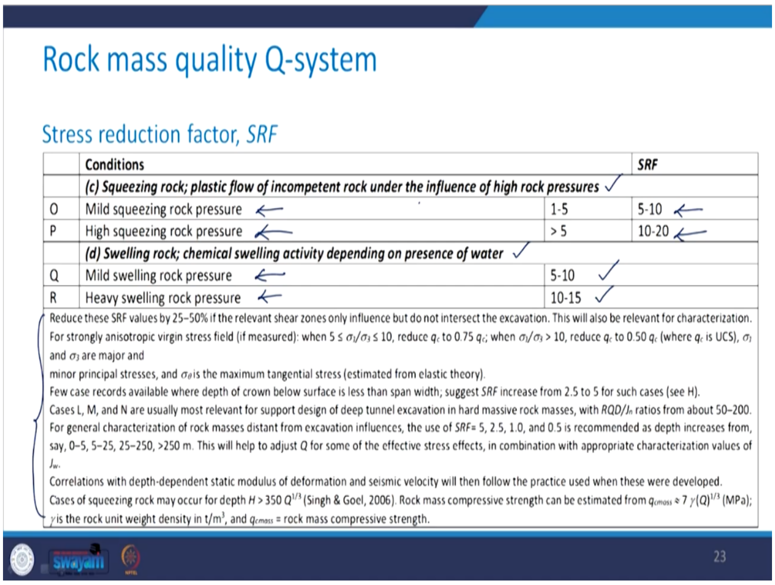


| | Conditions | | SRF |
|---|---|---|---|
| | *(c) Squeezing rock; plastic flow of incompetent rock under the influence of high rock pressures* | | |
| O | Mild squeezing rock pressure | 1-5 | 5-10 |
| P | High squeezing rock pressure | > 5 | 10-20 |
| | *(d) Swelling rock; chemical swelling activity depending on presence of water* | | |
| Q | Mild swelling rock pressure | | 5-10 |
| R | Heavy swelling rock pressure | | 10-15 |

Reduce these SRF values by 25–50% if the relevant shear zones only influence but do not intersect the excavation. This will also be relevant for characterization.
For strongly anisotropic virgin stress field (if measured): when $5 \le \sigma_1/\sigma_3 \le 10$, reduce $q_c$ to 0.75 $q_c$; when $\sigma_1/\sigma_3 > 10$, reduce $q_c$ to 0.50 $q_c$ (where $q_c$ is UCS), $\sigma_1$ and $\sigma_3$ are major and
minor principal stresses, and $\sigma_\theta$ is the maximum tangential stress (estimated from elastic theory).
Few case records available where depth of crown below surface is less than span width; suggest *SRF* increase from 2.5 to 5 for such cases (see H).
Cases L, M, and N are usually most relevant for support design of deep tunnel excavation in hard massive rock masses, with $RQD/J_n$ ratios from about 50–200.
For general characterization of rock masses distant from excavation influences, the use of *SRF* = 5, 2.5, 1.0, and 0.5 is recommended as depth increases from, say, 0–5, 5–25, 25–250, >250 m. This will help to adjust *Q* for some of the effective stress effects, in combination with appropriate characterization values of $J_w$.
Correlations with depth-dependent static modulus of deformation and seismic velocity will then follow the practice used when these were developed.
Cases of squeezing rock may occur for depth $H > 350\, Q^{1/3}$ (Singh & Goel, 2006). Rock mass compressive strength can be estimated from $q_{cmass} \approx 7\,\gamma(Q)^{1/3}$ (MPa); $\gamma$ is the rock unit weight density in t/m$^3$, and $q_{cmass}$ = rock mass compressive strength.

Third one is for the squeezing rock, where the plastic flow of incompetent rock under the influence of high rock pressures are there. In case if you have mild squeezing rock pressure, the SRF will take the rating between 5 to 10; and for high squeezing rock pressure, this will be 10 to 20. This was for the squeezing rock. Now, for the swelling rock, where the chemical swelling activity depends upon the presence of water.

If you have mild swelling rock pressure, you will have the rating of 5 to 10; and in case of the heavy swelling rock pressure, you will have the rating 10 to 15. And there are few notes which are given here at the bottom of this table. Please read these so that, in order to have any kind of deviation as far as these tables are concerned; so you need to take the note of these comments which are given here and assign the rating accordingly.

So, today we discussed about the Q-system or rock mass quality system. And we learned the 6 parameters which influence this parameter, which are used to obtain the Q-index. Using these 6 tables and matching these conditions with what you have in the field, one can assign the rating of each of these parameters. And using the expression given for the index Q which has 3 quotient, one can calculate the index Q.

So, in the next class, we will see that, after obtaining the index Q, how one can classify the rock mass; what are the various applications of this Q-system. And we will also see the physical interpretation of each of the 3 quotient which appear in the expression, for the evaluation of Q-index. Thank you very much.