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Support Design Consideration for Roof and Side Wall against Wedge Failure In Production Level of Maddhapara Granite Mine, Bangladesh

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Abstract—The geological map of the production level was examined and found the potential areas of wedge with in the production level. In this structurally controlled instability prone area the optimum support for the openings of the production level was designed by kinematics analysis for potential wedges. The areas having minimum three sets of joint up to maximum four sets of joints were considered for wedge failure analysis in both roof and side walls.Thewight of the wedge in all the potential areas of failure was calculated and Rock bolts have been considered in support design to keep the falling wedges in stable position. Thenumber of bolts that would be needed in roof and side wall of loop drifts were determined from roof support pressure.So in this research it has been strablished that rock bolting is the most effective support design for Maddhapara Granite Mining Company (MGMCL) than shortcreet or concrete linings.

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Index Terms—Support Design, Wedge failure, Rock Bolt, Maddhapara Granite Mine.

1 Introduction

Tunnels which constructed in jointed rock masses, the most common types of failure are wedge falling or sliding off along a plane or intersecting line (along two planes) in roofs as well as in side walls of the openings. Bedding planes and joints, which separate the rock mass into discrete but interconnected pieces, form these wedges. These wedges should be supported and treated properly to make the underground tunnel stable. For this purpose the geological map of (MGMCL), 2010 was analysed properly and ultimately the number of bolt that will be needed for optimum support system design were determined.

2 Study Area

The Maddhapara Hardrock mine is located at Madhayapara village under Parbatipur Thana, Dinajpur district, and Rajshahi division. The MGMC lies between latitude 25° 23'43" and 25°34'43" N and longitude 89°03'34"E and 89°05'04" E. It is about 13kms north east of Phulbari Railway station. The location map of the study area and the map of the production level are given in figure1.

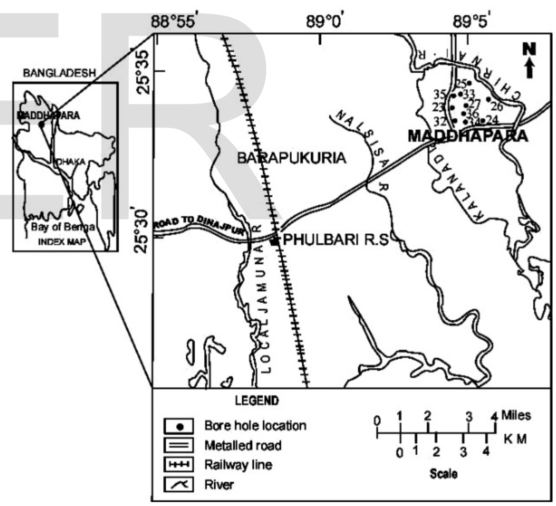

Fig. 1. Location map of the study area (Modified after Rahman, 1987 and Schematic diagram of Madhayapara Granite Mining Company (Source: MGMCL, 2010).

3 Dealing with Wedge in Production Level

The following steps were followed to deal with wedge failure problems in the drifts-

1. Determination of average dips and dips direction of joint sets.
2. Identification of potential wedges which can slide or fall from roof as well as from side wall.
3. Calculation of support for wedges, required to make the tunnel stable.

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3.1 Determination of Joint sets

The geological map of MGMCL, 2010 of the production level has been analyzed systematically and found the following joint sets through out the production level shown in table 1.

TABLE 1
JOINT SETS NUMBER IN PRODUCTION LEVEL

Set No.	Symbol	Dip Direction	Dip Angle	Number of joints
Set-1	J_1	180±10	80±11	88
Set-2	J_2	80±9	85±9	98
Set-3	J_3	275±11	75±12	74
Set-4	J_4	335±12	75±10	15
Set-5	J_5	15±9	75±9	14
Set-6	J_6	130±8	50±15	8
Set-7	J_7	220±7	70±5	9

There are some areas having one, two, three and maximum four sets of joints at a time. The areas having minimum three sets of joint up to maximum four sets of joints were considered for wedge failure analysis as at least three sets of joints are needed to form a wedge. Within the same location more than one wedge failure porn areas have been identified with subunits. The locations of three and four sets of joint in the production level are shown in the figure 2 and tabulated in table 2.

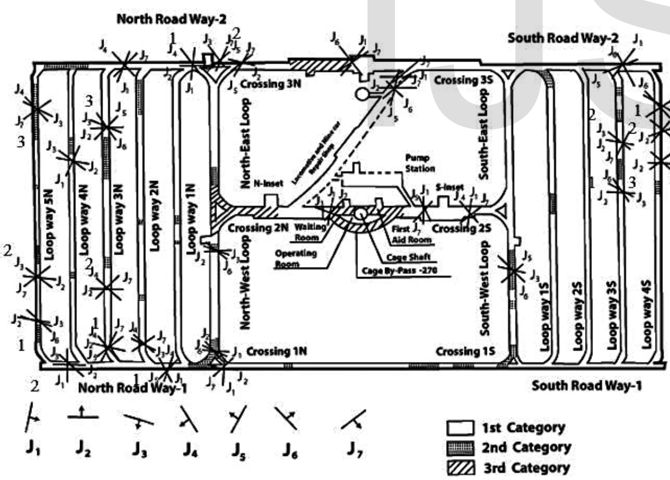

Figure 2 Joint sets in Production Level of Madhayapara Hard Rock Mine, Bangladesh.

TABLE 2
JOINT SETS IN THE PRODUCTION LEVEL

Number of joint sets	Location (Unit)	Subunit	Joint sets
Three sets of joint	North road way-1	1	J_1,J_5,J_4
		2	J_2,J_1,J_3
	Loop way 1N	1	J_3,J_2,J_6
		2	J_2,J_7,J_3
		3	J_3,J_7,J_4
	Loop way-2N		J_2,J_3,J_1
	Loop way-3N	1	J_4,J_2,J_7
	Loop way-4N		J_7,J_3,J_4
	North road way-2		J_1,J_4,J_7
	Crossing 3N	3	J_2,J_5,J_7
	Crossing 1N	2	J_2,J_1,J_7
	North-west loop		J_6,J_3,J_2
	Loaded car drift		J_1,J_7,J_6
	Locomotive and mine car repair shop	1	J_2,J_1,J_5
	Loop way 4s	1	J_5,J_6,J_3
		2	J_3,J_1,J_2
		3	J_4,J_2,J_5
	Loop way 3s	1	J_3,J_7,J_2
		2	J_2,J_6,J_3
	South roadway-2		J_5,J_6,J_1
	South west loop		J_3,J_6,J_5
	South Inset	1	J_1,J_7,J_4
		2	J_2,J_7,J_1
	West Inset		J_1,J_2,J_3
Four sets of joint	Loop way 3N	2	J_5,J_3,J_2,J_6
		3	J_2,J_7,J_4,J_5
	Crossing 3N	1	J_5,J_4,J_1,J_2
		2	J_5,J_2,J_3,J_7
	Crossing 1N	1	J_3,J_6,J_1,J_2
	Locomotive and mine car repair shop	2	J_6,J_2,J_7,J_5

3.2 Identification of potential wedge

Wedge failure in roof and side wall of the roadway was analyzed by applying the Kinemetric analysis of Underground wedge of Hoek and Brown, 1982; Hudson and Harrison, 1997;Badrul, 2006. According to it wedge failure in the tunnel have categorized into i) wedges in roof and ii) wedges in side wall.

3.2.1 Wedges in Roof

In roof three types of wedges have been considered, these are as follows i) falling wedges ii) wedge failure along two planes (along line of intersection)iii) wedge failure on one plane.The wedge failure analysis of roof wedges have been analyzed into two categories

A. Area with three sets of joint
B. Area with four sets of joint

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A. Area with three sets of joint

The weight of wedge that can be formed have been determined by following equations:

$$Wedge\ Area = \frac{1}{2} \times base\ length \times height\ of\ base \qquad (1)$$

$$Volume\ of\ wedge = \frac{1}{3} \times wedge\ area \times height\ of\ wedge \qquad (2)$$

$$Weight\ of\ wedge = volume\ of\ wedge \times volumetric\ weight\ of\ wedge \qquad (3)$$

The volumetric weight of hard rock ranges from 28 to 35 KN/m³ (Hoek and Brown 1985) and the volumetric weight of the hard rock mine was consider as 30 KN/m³. The result of the wedge calculation is given in table 3.

TABLE 3
WEDGE FAILURE IN ROOF OF TUNNEL FORMED BY THREE SETS OF JOINTS

Location	Width (m)	Subunit	Joint sets	Failure mode	Base length (m)	Height of Base (m)	Height of Wedge (m)	Volume of wedge(m^3)	Weight of wedge (kN)
North road way-1	4.6	1	J_1,J_5,J_4	Fall	4.6	0.8	1.4	0.858	25.74
	9.2	2	J_2,J_1,J_3	Fall	30.4	9.2	20.7	964.89	28946.88
Loop way 1N	2.3	1	J_3,J_2,J_6	Fall	2.35	0.5	0.9	0.176	5.28
	2.3	2	J_2,J_7,J_3	Fall	2.3	0.45	1.05	0.181	5.43
	2.3	3	J_3,J_7,J_4	Slide on plane-J_3-75	2.35	1.75	5.25	3.60	107.94
Loop way-2N	2.3		J_2,J_3,J_1	Fall	2.35	0.58	1.6	0.363	10.89
Loop way-3N	2.3	1	J_4,J_2,J_7	Fall	2.5	1.5	2.4	1.5	45
Loop way-4N	2.3		J_7,J_3,J_4	Slide on plane-J_3-75	2.35	1.75	5.25	3.60	107.94
North road way-2	2.3		J_1,J_4,J_7	Slide on plane-J_3-75	2.35	1.75	5.25	3.60	107.94
Crossing 3N	9.2	3	J_2,J_5,J_7	Fall	12.1	3.7	5.8	43.27	1298.1
Crossing 1N	4.6	2	J_2,J_1,J_7	Slide on plane-J_1-80	7.1	2.9	8.85	30.37	911.02
North-west loop	4.6		J_6,J_3,J_2	Fall	4.65	0.9	1.3	0.906	27.18
Loaded car drift	7.6		J_1,J_7,J_6	Slide on plane-J_1-80	7.6	6.27	10.24	81.32	2439.54
Locomotive and mine car repair shop	10.73	1	J_2,J_1,J_5	Slide on plane-J_2-85	12.1	4.6	12.6	116.886	3506.58
Loop way 4s	2.3	1	J_3,J_5,J_6	Fall	2.55	1.3	0.85	0.47	14.1
		2	J_1,J_2,J_3	Fall	0.625	1.67	1.4	0.29	8.7
		3	J_5,J_2,J_4	Stable					
Loop way 3s	2.3	1	J_3,J_2,J_7	Fall	2.35	0.25	1.3	0.13	3.9
		2	J_2,J_3,J_6	Fall	2.83	0.45	0.675	0.12	3.6
South West loop			J_5,J_6,J_3	Fall	5.05	2.65	2.1	4.08	140.4
North Inset-1	4.6		J_1,J_2,J_3	Fall	16.8	4.55	1.5	19.11	573.3
South Inset-1	4.6	1	J_1,J_4,J_7	Intersection J_1-80 J_4-75	4.6	1.4	6.78	7.28	218.4
		2	J_1,J_2,J_3	Fall	13.7	5.7	15.4	39.04	200.4
South roadway-2	4.6	Stable							

B. Area with four sets of joint

In case of four sets of joint, four subunits were made using three joint sets at a time and then did the wedge calculation and found the greatest weight of wedge that could be formed by each four sets of joint and the result is given in table 4.

TABLE 4
WEDGE FAILURE IN ROOF OF TUNNEL FORMED BY FOUR SETS OF JOINTS

Location	Width (m)	Subunit	Joint sets	Failure mode	Base length (m)	Height of Base (m)	Height of Wedge (m)	Volume of wedge (m^3)	Weight of wedge (kN)
Loop way 3N(Sub-2)	2.3	1	J_2,J_5,J_3	Slide on plane-J_5-75	4.6	1.1	2.6	2.19	65.77
		2	J_7,J_2,J_3	Fall	4.65	0.9	1.45	1.01	30.3
		3	J_5,J_6,J_3	Slide on plane-J_3-75	7.25	2.55	6.25	19.25	577.68
		4	J_5,J_2,J_7	Fall	6.6	1.95	3.55	7.61	228.3
Loop way 3N(Sub-3)	2.3	1	J_4,J_2,J_7	Fall	10	6	6	60	1800
		2	J_4,J_5,J_7	Slide on plane-J_4-75	20	6	16	319.97	9599.04
		3	J_5,J_2,J_7	Fall	13.6	4	6.4	58.026	1740.78
		4	J_4,J_2,J_5	-	-	-			-
Crossing 3N (sub-1)	9.2	1	J_1,J_4,J_5	Fall	9.2	1.5	3.8	8.74	262.2
		2	J_2,J_4,J_5	-					
		3	J_1,J_2,J_5	Slide on plane-J_5-75	9.5	2.3	6	21.85	655.43
		4	J_1,J_2,J_4	Fall	9.4	3.8	8	47.62	1428.6
Crossing 3N (sub-2)	4.6	1	J_5,J_2,J_3	-	-	-			
		2	J_5,J_2,J_7	Fall	12	3.5	5.7	39.9	1197
		3	J_5,J_3,J_7	Slide on plane-J_3-75	11.3	3.9	14.1	103.55	3106.63
		4	J_3,J_2,J_7	Fall	27.6	7.7	18	637.56	19126
Crossing 1N (sub-1)	9.2	1	J_1,J_2,J_3	Fall	10.8	2.4	7	30.24	907.2
		2	J_1,J_6,J_3	Intersection J_3-75 J_1-80	9.8	4.3	2.8	19.66	589.90
		3	J_3,J_2,J_6	Fall	9.5	1.8	2.8	7.98	239.4
		4	$J1,J_2,J_6$	Intersection J_2-85 J_1-80	10	57	8.2	778.92	23367.66
Locomotive and mine car repair shop	7.73	1	J_6,J_2,J_7	Intersection J_7-70 J_6-50	12.60	6.18	33.71	437.44	13123.34
		2	J_5,J_2,J_7	Fall	25.89	7.93	12.83	439.01	13170.3
		3	J_5,J_6,J_7	Fall	25.77	10.50	10.26	462.70	13881
		4	J_5,J_2,J_6	Slide on plane-J_2-85	13.06	8.86	12.82	247.21	7416.37

Considering the wedges in the roof, the maximum weight of wedge that could be formed by each four sets of joint with their locations is given in table 5.

TABLE 5
MAXIMUMWEDGE FORMED BY FOUR SETS OF JOINTS IN ROOF

Location	Sub unit	Joint sets	Failure Mode	Weight of wedge
Loop way 3N(Sub-2)	4	J_5,J_2,J_7	Slide on plane-J_3-75	577.68
Loop way 3N(Sub-3)	3	J_5,J_2,J_7	Slide on plane-J_4-75	9599.04
Crossing 3N (sub-1)	4	J_1,J_2,J_4	Fall	1428.6
Crossing 3N (sub-2)	4	J_3,J_2,J_7	Fall	19126
Crossing 1N (sub-1)	4	$J1,J_2,J_6$	Intersection J_2-85 J_1-80	23367.6
Locomotive and mine car repair shop	3	J_5,J_6,J_7	Fall	13881

3.1.2 Wedges in Sidewall

Free fall of wedge can not occur in case of side wall, because wedges in sidewall always slide along plane or planes. So two types of failure was analysed by using the kinematics analysis of potential wedges. So in case of sidewall wedges divided in to two categories i) wedges falling along two planes ii) wedges falling along one plane. The wedge failure analysis of roof was analyzed into two categories:

A. Areas with three sets of joint

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B. Areas with four sets of joint

A. Areas with three sets of joint

Areas with three sets of joint, formation of wedges in sidewall have been examined by means of Kinemetric analysis of underground wedge. There is only one possibility of side wall wedge failure located at North road way-1 subunit 2 of the prevailing joints in the production level. To determine the weight of wedge the same equations (equation1, 2 and3) have been used as used for roof wedge. The results are given in table 6.

TABLE 6
WEDGE FAILURE IN SIDEWALL WITH THREE SETS OF JOINTS

Location	Width	Subunit	Joint sets	Failure mode	Base length (m)	Height of Base (m)	Height of Wedge (m)	Volume of wedge (m^3)	Weight of wedge (kN)
North road way-1	4.6	1	J_1,J_5,J_4	No wedge formed	-		—	-	-
	9.2	2	J_2,J_1,J_3	Plane j1/ 83	9.4	0.4	1.2	0.752	22.56
Loop way 1N	2.3	1	J_5,J_2,J_6	No wedge formed	-		—	-	-
	2.3	2	J_2,J_7,J_3	No wedge formed	-		—	-	-
	2.3	3	J_5,J_7,J_4	No wedge formed	-		—	-	-
Loop way-2N	2.3	-	J_2,J_3,J_1	No wedge formed	-		—	-	-
Loop way-3N	2.3	1	J_4,J_2,J_7	No wedge formed	-		—	-	-
Loop way-4N	2.3	-	J_7,J_5,J_4	No wedge formed	-		—	-	-
North road way-2	2.3	-		No wedge formed		--	-	-	
Crossing 3N	******	3	J_2,J_5,J_7						
Crossing 1N		2	J_2,J_1,J_7	No wedge formed	-		—	-	-
North-west loop	4.6	-	J_6,J_5,J_2	No wedge formed	-		—	-	-
Loaded car drift	7.6	-	J_1,J_7,J_6	No wedge formed	-		—	-	-
Locomotive and mine car repair shop	10.73	1	J_2,J_1,J_5	No wedge formed	-		—	-	-

B. Area with four sets of joint

In case of four sets of joint four subunits have been made using three joint sets at a time and then did the wedge analysis and found the weight of wedge that can be formed by each four sets of joints. The results are given in table 7.

TABLE 7
WEDGE FAILURE IN SIDEWALL WITH FOUR SETS OF JOINTS

Location	Width	Subunit	Joint sets	Failure mode	Base length (m)	Height of Base (m)	Height of Wedge (m)	Volume of wedge(m^3)	Weight of wedge (kN)
Loop way 3N(Sub-2)	2.3	1	J_2,J_5,J_3	No wedge formed					
		2	J_7,J_2,J_3						
		3	J_5,J_6,J_3						
		4	J_5,J_2,J_7						
Loop way 3N(Sub-3)	2.3	1	J_4,J_2,J_7	No wedge formed					
		2	J_4,J_5,J_7						
		3	J_5,J_2,J_7						
		4	J_4,J_2,J_5						
Crossing 3N (sub-1)	9.2	1	J_1,J_4,J_5	No wedge formed					
		2	J_2,J_4,J_5						
		3	J_1,J_2,J_5						
		4	J_1,J_2,J_4	Plane-c 88	101.6	2.8	9.4	445.68	13370.4
Crossing 3N (sub-2)	4.6	1	J_5,J_2,J_3	No wedge formed					
		2	J_5,J_2,J_7	Plane C/ 84	17.6	3	3.4	29.92	897.6
		3	J_5,J_3,J_7	No wedge formed					
		4	J_3,J_2,J_7	Plane a/ 83	19.5	1.3	2.0	8.45	253.5
Crossing 1N (sub-1)	9.2	1	J_1,J_2,J_3	No wedge formed					
		2	J_1,J_6,J_3	No wedge formed					
		3	J_3,J_2,J_6	No wedge formed					
		4	J1,J_2,J_6	Intersection Bc/ b-77 c-56	40	8	8	426.66	12799.8
Locomotive and mine car repair shop	7.73	1	J_6,J_2,J_7	No wedge formed					
		2	J_5,J_2,J_7	No wedge formed					
		3	J_5,J_6,J_7	Intersection Ac/ a-88 c-78	29.86	9.80	13.52	659.38	19781.4
		4	J_5,J_2,J_6	Slide on plane-J_2-85	13.06	8.86	12.82	247.21	7416.37

The maximum weight of wedges in side wall with their location in case of four sets of joint are shown in table 8.

TABLE 8
MAXIMUM WEIGHT OF SIDE WALL WEDGE IN CASE OF FOUR SETS OF JOINT

Location	Sub units	Failure mode	Weight of wedge
Crossing 3N (sub-2)	2	Plane C/ 84	897.6
Crossing 3N (sub-1)	4	Plane-c 88	13370.4
Crossing 1N (sub-1)	4	Intersection Bc/ b-77 c-56	12799.8
Locomotive and mine car repair shop	3	Intersection Ac/ a-88 c-78	19781.4

4 SUPPORT REQUIREMENTS

Wedges that formed with in the tunnel are needed to be supported to make the tunnel stable. Roof wedges occur as soon as the base of the wedge is fully exposed by the tunnel and side wedges, slide along one plane or in the line of intersections of two planes. So in order to determine the requirements of support system for roof and sidewall different approaches have been applied. Support categories have been divided in to two categories-

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A. Support pressure for Falling Wedges
B. Support pressure for Sliding Wedges

A. Support Pressure for Falling Wedges

Rock bolts have been considered in support design to keep the falling wedges in stable position. For falling wedges reinforcement has been considered to support the full dead weight of the wedge. Considering the allowance for errors and poor quality reinforcement for roof wedges, the total tension applied to the rock bolts were considered to 1.5×W, to make the factor of safety of 1.5 according to the recommendation of Hoek (2002). The support pressure that would be needed to make the roof wedges stable are given in table 9.

TABLE 9
SUPPORT FOR FALLING WEDGES

Intersections	Location	Weight of wedge (KN)	Support pressure (Wχ1.5) (KN)
THREE SETS OF JOINT	North Roadway-1 Sub-2	964.89	1447.33
	North Roadway-1 Sub-1	25.74	38.61
	Loop way 1N Sub-2	5.43	8.14
	Loop way 1N Sub-1	5.28	7.92
	Loop way 3N Sub-1	45	67.5
	Loop way 4N	10.89	16.33
	Crossing 3n Sub-3	1298.1	1947.15
	North West Loop	27.18	40.77
	Loop way 4s sub-1	14.1	21.15
	Loop way 4s sub-2	8.7	13.05
	Loop way 3s sub-1	3.9	5.85
	Loop way 3s sub-2	3.6	5.4
	South west loop	140.4	210.6
	North Inset-1	573.30	859.95
FOUR SETS OF JOINT	Crossing 3n (sub-1)-4	1428.6	2142.9
	Crossing 3n (sub-2)-4	19126	28689
	Locomotive and mine car repair shop (sub-2)-3	13881	20821.5

B. Support pressure for Sliding Wedges

Sliding wedges slide along surface or surfaces and the geometry of sliding wedge (Hoek &Brown 1982) is shown in figure 3.

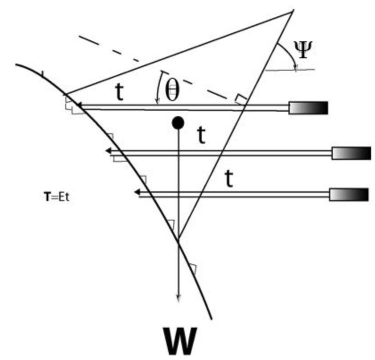

Fig. 3. Geometry of sliding wedge.

The total bolt load that is needed to stabilize the wedge and resist its sliding can be calculated by the following the equation of Hoek and (Brown 1985):

$$T = \frac{W\left(F..Sin\Psi - \cos\Psi.Tan\phi\right) - CA}{Cos\vartheta.Tan\phi + F.Sin\vartheta}$$

Where,

w = *Weight of wedge*
T = *Load in the bolt*
A = *Base area of the sliding surface*
ψ = *Dip of the sliding surface*
ϑ = *Angle betweenplunge of bolt and the normal to the sliding surface*
C = *Cohesivectrength of the sliding surface*
ϕ = *Frictionangle of sliding surface*

Hoek and Brown, 1985 recommended that the Bolts or cables should be inclined so that the angle θ is in between 15-30 since the inclination will induce the highest shear resistance along the sliding surface. The angle was taken of 27° to have better stability and the cohesive strength was taken to zero as there is no cohesion along the discontinuities. Applying the equation mentioned above for total support load required to stabilize the sliding wedges in roof are given in table 10 and for side wall in table 11.

TABLE 10
SUPPORT FOR SLIDING WEDGE IN ROOF OF TUNNEL

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Intersections	Location	Sub units	Failure mode	Weight of wedge	Support pressure needed (MPa)
Three sets of joint	Crossing 1N Sub-2		Plane J_1 80°	911.02	746.277
	North roadway-2		Plane J_7 70°	119.13	84.22
	Loop way 1n Sub-3		Plane J_3 75°	107.94	82.68
	Loop way 4N		Plane J_3 75°	107.94	82.68
	Loaded car drift		Plane J_1 80°	2439.54	
	South inset	1	Intersection J_1-80 J_4-75	218.4	178.91 +167.29= 346.2
	South inset	2	Plane J_1-80	6012	4924.83
Four sets of joint	Locomotive and mine car repair shop Sub-2	1	Intersection A(J_7)-70° C(J_6)-50°	12123.34	8571.19 + 5120.16= 13691.35
		4	Plane A (J_2-85)	7416.37	6423.39
	Loop way 3N Sub-3	2	Plane A (J_4-75)	9599.04	7352.82
	Crossing 1N Sub-1	2	Intersection A(J_3)-75° C(J_1)-80°	589.90	451.86 + 483.22= 935.08
		4	Intersection A(J_2)-85° C(J_1)-80°	23367.66	20238.4 + 19142.01= 39380.40
	Crossing 3N Sub-1	3	Plane A (J_5)-75	655.43	502.05
	Loop way 3N Sub-2	1	Plane A (J_5)-75	65.77	50.38
		4	Plane A (J_3)-75	577.68	422.49
	Crossing 3N Sub-2	3	Plane A (J_3)-75	3106.63	2379.66

TABLE 11
SUPPORT FOR SLIDING WEDGE IN SIDE WALL OF TUNNEL

Intersection	Location	Subunit	Failure mode	Weight of wedge	Support pressure
Three sets of joint	North road way-1	2	Plane a′-83	22.56	19.13
Four sets of joint	Crossing 3N Sub-1	4	Plane c′-88	13370.4	11914.86
	Crossing 3N Sub-2	2	Plane c′-84	897.6	769.46
		4	Plane a′-83	253.5	214.99
	Crossing 1N Sub-1	4	Intersection bc′ b-77 c-56	12799.8	10086.07 + 6589.34= 16675.41
	Locomotive and mine car repair shop Sub-2	3	Intersection Ac′ a-88 c-78	19781.4	17627.95 + 1579.99= 19207.94
		4	Plane J_2-85	7416.37	6423.39

5 SUPPORT DESIGN FOR WEDGES

Rock bolt has been considered as support system for making the wedges stable recommended byHoek and Brown, 1980. According to them the rock bolts are used to support potentially unstable wedges which are free to fall or slide under their own weight because these wedges move independently of the remainder of the rock mass.These supports are better to resist the eccentric load of the wedges than shortcreet or concrete linings.

The rock bolt with support carrying capacity of 100 KN has been considered for making the wedges stable. Number of bolts that would be needed in roof and side wall of loop drifts is given in table 12.

TABLE 12
NUMBER OF BOLTS IN ROOF AND SIDE WALL OF THE ROAD WAY

	Location	Roof Support pressure (KN)	Number of bolts in roof	Sidewall	Number of bolts in side wall
THREE SETS OF JOINT	North road way-1 sub-1	38.61	1	-	
	North road way-1 sub-2	43420.32	435	19.13	1
	Lop way 1N sub-1	7.92	1	-	
	Lop way 1N sub-2	8.145	1	-	
	Lop way 1N sub-3	82.68	1		
	Loop way 2N	16.34	1		
	Loop way 3n Sub-1	67.5	1		
	Loop way 4N	82.68	1		
	North roadway-2	84.22	1		
	Crossing 3N sub-3	1947.15	20		
	Crossing 1N sub-2	746.277	8		
	North west loop	40.77	1		
	Loaded car drift	1998.39	20		
	Locomotive and mine car repair shop Sub-1	13691.35	137		
Four sets of joint	Loop way 3N Sub-2	422.49	5		
	Loop way 3N Sub-3	7352.82	74		
	Crossing 3N Sub-1	2142.9	22	11914.86	120
	Crossing 3N Sub-2	28689	287	769.46	8
	Crossing 1N Sub-1	39380.41	394	16675.41	167
	Locomotive and mine car repair shop Sub-2	20821.5	209	19207.94	193

6 CONCLUSION

For structurally controlled instability porn area bolts are needed to support the wedge. For north roadway-1 subunit1 the number of bolt in roof is 1, for north roadway-1 subunit2 the number of bolt in roof is 435 and for sidewall is 1, for loop way1N sub-1, loop way1N sub-2, loopway1N sub-3, loop way 4N, North roadway2, north west loop the number of bolt in roof is 1, for crossing 3N sub-2 the number of bolt in roof is 20, for Crossing 1N sub-2 the number of bolt in roof is 8, for loaded car drift the number of bolt is 20, for locomotive and mine car repair shop sub-1 the number of bolt is 137, for loop way 3N sub-2 bolt number is 5 in roof, for loop way 3N sub-3 the number is 74 in roof, for crossing 3N sub-1 the number of bolt in roof is 119 and for sidewall is 120, for crossing 3N sub-2 the number of bolt in roof is 287 and for sidewall is 8 In crossing 1N sub-1 the number of bolt in roof is 394 and in sidewall is 167, for locomotive and mine car repair shop sub-2 the number of bolt in roof is 209 and in sidewall is 193. For newly explored area they can flow our support design for different categories of rock of different types of openings. In the disturbed areas they can use by inserting fiber reinforced shotcrete with silica foamed to over come the support problem.

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