Estimation of specific charge value before blast operation

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Abstract

Previous research postulates equations that estimate the specific charge value before blast and according to this value, some equations estimating the efficiency of a loader and crusher have been developed. It is necessary to clearly compute the specific charge value before a blast so that these developed equations can yield correct results. The length of a blast surface and the order number of a blast hole considerably affect the specific charge value (Tosun et al., 2013). In this study, a certain number of blast tests have been carried out in three different limestone quarries. An equation estimating the specific charge value before the blast was developed using the following parameters: the length of the blast surface, the order number of blast holes (the amount of burden on both ends of the holes of the blast surface), the height of the bench, uniaxial compressive strength of the rock, and the amount of explosives available in one meter of the blast hole.

Keywords: Before blast; blast efficiency; specific charge.

1. Introduction

The specific charge factor is generally defined as the amount of the explosive used in a blasted rock in unit amount. It is considered the most important parameter for determining the degree of disintegration in an open pit blast. Researchers have developed many equations estimating the pile size distribution formed after a blast using the specific charge parameter effectively in these equations (Langefors & Khilström, 1963; Bergmann *et al*., 1973; Holmberg, 1974; Larsson, 1974; Rustan, 1981; Cunningham, 1983 & 1987; Kou & Rustan, 1993; Chung & Katsabanis, 2000). Some researchers have investigated the effect of the specific charge parameter on crushing and grinding operations and developed equations related to these processes (Nielsen & Kristiansen, 1996; Workman & Eloranta, 2004; Kojovic *et al*., 1995; Tosun *et al*., 2012) that have again correlated the specific charge parameter with

the efficiency of loader, crusher and the pile density values from a blast occurrence. The specific charge parameter in open pit blast is used effectively by researchers. Specific charge value must be calculated accurately in order to get the right results so that the equations developed according to the specific charge value will give correct results. Determining the specific charge value is very complex since it depends on many variables, principally the physical characteristics of the rock mass. Therefore, researchers base their calculations on differing rock mass physical characteristics. In addition, empirical approaches have been proposed using values such as hole diameter, cross hole distance, and bench height intended for the application. To give examples of these approaches, some researchers have proposed equation 1 (Heinze et al., 1974) which considers the characteristics of the explosive, blast geometry, a rock's structural factor, and the compressive strength of the rock.

$$q = \frac{0.8.B.N.F_k.S_k.V_g.G_s.e.A.f}{K.a}, \tag{1}$$

Sk is the rock strength factor, V_g is the structural factor of the rock, Gs is the tension factor of the rock, e is the stemming factor, A is the explosive power factor, f is the design factor of the blasthole geometry, K is the factor of blasthole inclination, a is the bench height, m is the compaction factor of the explosive inside the hole.

Equation 2 (Langefors & Kihlstrom, 1963) is another equation expressed with blast geometry and rock blast factor. It is useful in the determination of the specific charge value:

$$q = \frac{\left(1,4.C_0.B^3\right)+0,4.C_0.B^2.(K-2B)}{n.K.B^2}, \tag{2}$$

where q is the specific charge value in kg/m^3; B is the burden in m; K is the bench height in m; C_o is the rock blast factor, n is the spacing, burden ratio.

Kou & Rustan (1993) expressed the rock blast factor (C_o) in equation 2 as uniaxial compressive strength, the dynamic elasticity module of the rock, and a variable of the heat energy of the reference explosive as:

$$C_o = \frac{\sigma_b^2}{2E_d\, Q_{er}}, \tag{3}$$

where σ_b is the uniaxial compressive strength of the rock in MPa; E_d is the dynamic elasticity module in MPa; Q_{er} is the heat energy of the reference explosive in Kj/kg.

However, in studies emphasizing that rock mass characteristics are important in the determination of the specific charge factor, Hoek&Bray, (1981) proposed equation 4 that considers the frequency of fissure and the effective internal friction angle as an empirical approach:

$$q = 1{,}4.\, tan\emptyset / \sqrt[3]{\frac{Number\ of\ fissures}{Meter}} \tag{4}$$

Accordingly, high correlations were obtained and empirically proposed in studies solely aimed at finding the specific charge value as well as mechanical characteristics of a rock material (Equations 5- 9):

$$q = 0{,}1268.\, e^{(\sigma_b \cdot 0{,}00808)} \quad \text{(r=0.95)}, \tag{5}$$

$$q = 0{,}116.\, e^{(\sigma_ç \cdot 0{,}1014)} \quad \text{(r=0.93)}, \tag{6}$$

$$q = 0{,}2349.\, Tan\emptyset^{0{,}557} \quad \text{(r=0.68)}, \tag{7}$$

$$q = 0{,}1156 + c.\, 0{,}072 \quad \text{(r=0.65)}, \tag{8}$$

$$q = 0{,}019 + 2{,}038x10^{-4}.\, d \quad \text{(r=0.99)}, \tag{9}$$

where $\sigma_ç$ is the tensile strength of the rock in MPa; $\emptyset$ is the internal friction angle in Degree; c is the cohesion in MPa; d is the density of the rock in KN/m^3.

In addition, the relationship between technological characteristics of a rock mass and the specific charge value has been investigated. Equation 10 was proposed by Toper (1988):

$$q = 0{,}472.\, I_p^{\,-0{,}4538} \quad \text{(r=0.92)}, \tag{10}$$

where I_p is the drillability Index in [(m/h).(inch)^2]/(10^{-3}.lb.rpm).

These previous studies show that the determination of the specific charge value has been estimated by using only physical and mechanical characteristics of the rock or by only using one average blast hole. In addition, some fixed factors given in the equations are the same values for each site, making the utilization of determined factors difficult. Therefore, the amount of material formed as a result of blast is generally calculated by a multiplication of the average burden, spacing, and bench height parameters (blast hole geometry). The specific charge value is determined by dividing this value by the amount of explosive used.

As stated, the specific charge value is generally defined as according to blast hole geometry . There is a major difference when the specific charge value is calculated according to blast hole geometry. When the specific charge value is calculated according to the total amount of material formed as a result of blast, more accurate results are given in terms of the size distribution. Using the specific charge value calculated according to blast hole geometry in blast operations with short blasting surface gives terrible results and should not be used. (Tosun *et al*., 2013). Therefore, it is important to clearly determine the total amount of material formed as a result of a blast so that the specific charge value before a blast can be calculated.

During a blasting operation, some materials explode because the shared blast hole has an influence on both side of the holes and at the back end sides of the blast holes. This also occurs in the back region of the blast surface. In this case, the length of the blast surface is correlated with the impact of the back region of the blast surface. The order number of the blast hole is also correlated and directly proportional to the lateral impact of the share blast hole influence at both end sides of the blast holes. How long or short the blast surface is and the order number of the blast holes will change the total amount of material which occurs as a result of the blast. Therefore, there will be an effect on the specific charge value. Particularly in blast operations with a short blasting surface and a high order number of blast holes, the majority of material blasted will be high. This is because of the effect of the share blast hole influence at both end sides of the blast holes and at the back region of the blast surface. Such a situation considerably changes the specific charge values calculated according to previous equations. The generation of an equation estimating the amounts of materials blasted due to the effect of the shared blast hole influence at both end sides of the blast holes and the back region of the blasting surface is important in order to correct calculations for specific charge values.

In this study, some blast tests were carried out in three limestone quarries with differing characteristics. The sites belong to BATIÇİM (Western Anatolian Cement Plant) and is referenced as the Arkavadi, Aravadi and Upper Aravadi. The volume of material values were primarily calculated according to blast hole geometry in performed blast tests, and then all the amounts of materials formed as a result of the blasts were determined by measuring using the weighbridge belonging to the company. Therefore, the volume of material values additionally blasted due to the length of the blast surface and the order number of blast holes was calculated as real, and an equation estimating these values was formed. For the study's equation, the following parameters were used:

- the length of the blast surface;
- the order number of the blast hole (the amount of burden of both end holes of the blasting surface);
- the bench height;
- the uniaxial compressive strength of the rock; and,
- the amount of explosive found in one meter of the blast hole (blast hole diameter effect).

Since the blasting processes were always in the same direction and were designed in performed blast tests, discontinuity characteristics of the blast surfaces remained constant, so they were not included in the generated equation. The total of the amount of material were calculated according to blast hole geometry (average burden × average spacing × average bench height × number of holes), and the equation was clearly able to calculate the amount of all materials formed as a result of blast. The specific charge values were also determined for each blast test by dividing the total amount of explosives used in the blast process by the amount of all materials formed as a result of blast.

2. Field and laboratory studies

Twenty-three blast tests were carried out: 8 in the Arkavadi limestone quarry, 6 in the Aravadi limestone quarry, and 9 in the Upper Aravadi limestone quarry. Figure 1 gives the locations of the quarries.

Fig. 1. Location of blast site quarries

During the blast field studies, discontinuity characteristics and controllable parameters such as blast hole diameter, bench height, blast hole length, burden, spacing, and the amount of explosives per hole were primarily measured in a sensitive manner. The volume of all the materials occurred as a result of blast and mechanical characteristics of the rock were also determined after the blast tests.

Discontinuity planar angle and vertical discontinuity range determine discontinuity characteristics of the blast surface. On the other hand, rock density factor and uniaxial compressive strength values of the rock constitute the rock resistances of the blast surface (Lilly, 1986). The vertical discontinuity range refers to the length of the blast surface per fissure, while the discontinuity plane angle determines the difference between the slope direction angle of the blast surface and slope direction angle of stratification surfaces. This difference value occurs regardless of whether the planar angle remains inside or outside the surface. Inclination direction and inclination angles belonging to blast surfaces have been measured by means of a compass. A measuring tape was used to determine the discontinuation range.

By always designing blasts in the same direction during the field research, discontinuity characteristics of the blast surfaces remained constant. Table 1 shows that the planar angle remained inside the surface for each blast test, and discontinuity range values were also measured as lower than 50 cm.

Table 1. Discontinuity characteristics of blast surfaces

Test no.	Inclination direction and inclination angles of blast surface planes (º)	Inclination direction and inclination angles of blast surface (º)	Discontinuity range (cm/ fissure)	At the surface
		Arkavadi Quarry		
1	323/44	150/85	62.31	
2	323/13	158/80	45.67	
3	280/23	144/82	34.21	
4	340/29	160/80	42.97	At the surface
5	276/26	117/85	26.65	
6	302/28	130/85	22.34	
7	309/40	130/84	40.16	
8	293/23	120/85	25.62	
		Aravadi Quarry		
1	135/16	78/83	24.57	
2	121/10	76/80	44.20	
3	161/43	92/81	18.23	At the surface
4	264/30	125/83	24.96	
5	269/25	128/81	29.56	
6	278/22	123/90	24.10	
		Upper Aravadi Quarry		
1	254/30	65/82	35.00	
2	260/30	66/83	39.72	
3	247/30	40/82	51.90	
4	247/30	45/83	48.43	
5	238/30	45/82	47.89	At the surface
6	240/30	51/81	38.60	
7	231/30	48/81	49.53	
8	218/31	35/82	44.78	
9	215/31	35/83	47.06	

The volume of material calculated according to blast hole geometry was:

$$Vgeo. = B.S.H.m, \tag{11}$$

Where B is the average burden in m; S is the average spacing in m; H is the average bench height in m; m is the number of blast hole, $Vgeo.$ is the volume of material calculated using blast hole geometry in m^3.

Controllable parameters; blast hole diameter, burden, spacing, blast hole length, and bench height were measured using a standard measuring tape. Amounts of explosives were determined as a result of observations in a very sensitive manner. Table 2 shows the aforementioned values and the material volumes calculated according to blast hole diameter at the test sites. The amount of explosive found in a unit meter of the blast hole depended on blast hole diameter, blast hole length, and explosive density. The same ANFO type explosive was used, but the blast hole lengths and diameters differed for each blast.

Table 2. Controllable blast values from study sites

Test no	Number/order of blast holes	B	S	D	H	L	Q_{tot}	Qe	V_{geo}
				Arkavadi Quarry					
1	30/2	2.50	2.44	89	9.5	11.0	1043.75	34.00	1738.50
2	20/2	2.77	2.25	89	10.5	11.0	662.50	32.50	1308.83
3	20/2	2.37	2.39	89	10.1	10.1	637.50	31.25	1144.19
4	12/2	2.84	2.11	89	10.1	10.1	370.00	30.00	726.28
5	18/2	2.55	2.10	89	10.1	10.1	561.25	30.00	973.54
6	18/2	2.17	2.43	89	12.5	13.7	861.25	47.00	1186.45
7	20/2	2.39	2.33	89	16.0	17.0	1362.50	67.50	1781.98
8	12/2	2.18	2.64	89	10.0	10.5	407.50	33.50	690.62
				Aravadi Quarry					
1	2/1	3.06	4.8	127	16.0	17.0	251.25	125.00	470.00
2	2/1	3.13	4.74	127	16.0	17.0	251.25	125.00	474.74
3	2/1	3.82	4.8	127	16.0	17.0	268.75	132.50	587.52
4	2/1	3.87	4.2	127	16.0	17.0	276.25	137.50	520.80
5	3/1	3.96	4.3	127	16.0	17.0	426.88	142.00	870.24
6	2/1	4.47	3.5	127	16.0	17.0	301.25	150.00	500.40
				Upper Aravadi Quarry					
1	6/2	3.23	2.93	89	12.35	13.0	328.75	54.00	700.19
2	7/2	2.56	2.96	89	12.00	12.0	254.38	36.00	637.58
3	20/2	2.96	2.92	89	12.60	14.0	937.50	46.00	2173.99
4	18/2	2.84	2.68	89	11.80	14.0	761.25	41.00	1616.13
5	7/2	2.68	2.79	89	12.00	14.0	304.38	43.00	627.75
6	18/2	3.00	2.70	89	12.00	14.0	761.25	42.00	1751.22
7	6/2	2.65	2.69	89	12.00	14.0	228.75	38.00	512.77
8	7/2	2.79	3.14	89	12.20	14.0	329.38	47.00	748.92
9	7/2	3.16	2.64	89	11.90	14.0	329.38	47.00	694.30

Where D is the hole diameter in mm; L is the average blast hole height, in m; $Qtot.$ is the the total amount of explosive material in kg; Qe is the the average amount of explosive material per blast hole in kg.

Resulting blast material was transported by company trucks to a crushing plant for the production of stone chips. All transported materials were weighed on site using the company's weighbridge. The volume of all material occurred as a result of blast was also calculated by dividing the amounts of obtained materials by unit volume weight of the rock (Table 3).

Table 3. Amount and volume of resulting blast test material

Test no.	Total resulting blast test material (tons)	Unit weight of rock (tons/m^3)	Total resulting volume of blast tests (m^3)
Arkavadi Quarry			
1	5512.330		2080.125
2	4156.980		1568.671
3	3721.760		1404.438
4	2447.660	2.65	923.6452
5	3167.980		1195.464
6	3814.880		1439.578
7	5987.430		2259.408
8	2272.540		857.562
Aravadi Quarry			
1	1607.070		606.440
2	1692.090		638.520
3	2454.440	2.65	926.200
4	2428.080		916.260
5	3989.730		1505.560
6	2442.760		921.800
Upper Aravadi Quarry			
1	2343.940		884.506
2	2350.100		886.830
3	7816.740		2949.713
4	4965.160		1873.645
5	2084.940	2.65	786.770
6	5861.800		2212.000
7	1673.460		631.494
8	2653.400		1001.283
9	2305.120		869.857

Physical and mechanical tests were applied to the samples provided from the regions where blast tests had been carried out in a rock mechanics laboratory. As a result of these tests, the density and unit volume weight and uniaxial compression strength values were determined. Because indirect tensile strength is also an important factor (Zhou *et al.*, 2018), Brazilian tests were applied on samples (Table 4).

Table 4. Physical and mechanical characteristics of studied material

Study site	Average unit volume weight (gr/cm³)	Average density (gr/cm³)	Average uniaxial compression strength (MPa)	Average indirect tensile strength
Arkavadi Quarry	2,65± 0,07	2,74 ± 0,002	38.004± 1.75	6.41± 0.55
Aravadi Quarry	2,65± 0,003	2,73 ± 0,003	29.305± 5.35	4.90± 0.58
Upper Aravadi Quarry	2,65± 0,004	2,70 ± 0,0025	20.3325± 2.07	3.40± 1.35

3. Evaluation

Table 5 shows the study results including the difference between the volume of total resulting blast material amounts, the volume of material amounts calculated according to blast hole geometry, the volume of material values blasted the effect of the share blast hole influence at both end sides of the blast holes and at the back region of the blast surface.

Fig. 2 gives the amount of material blasted due to the effects of a shared blast hole on both end sides of the blast holes and the amount of material that was blasted because of the impact of the back region on the blast surface. The value is directly correlated with the burden amount (a and b).

Figure 2a shows a single row blast design, while Figure 2b shows a double row blast design.

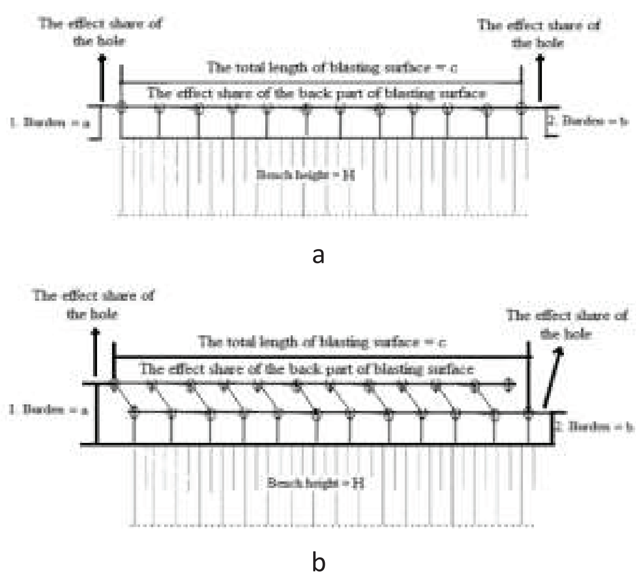

Fig. 2. Parameters effecting amount of material blasted additionally (except for amount of material calculated according to blast hole geometry)

Table 5. Volume of material values blasted due to effect of sharing on both end sides of blast holes and back region of blast surface

Test no.	V_{tot} (m³)	V_{geo} (m³)	V_{add} (m³)
	Arkavadi Quarry		
1	2080.125	1738.500	341.625
2	1568.671	1308.825	259.846
3	1404.438	1144.189	260.249
4	923.6452	726.279	197.366
5	1195.464	973.539	221.925
6	1439.578	1186.448	253.130
7	2259.408	1781.984	477.424
8	857.562	690.624	166.938
	Aravadi Quarry		
1	606.440	470.000	136.440
2	638.520	474.740	163.780
3	926.200	587.520	338.680
4	916.260	520.800	395.460
5	1505.560	870.240	635.320
6	921.800	500.400	421.400
	Upper Aravadi Quarry		
1	884.506	700.190	184.320
2	886.830	637.580	249.250
3	2949.713	2173.990	775.720
4	1873.645	1616.130	257.520
5	786.770	627.750	159.020
6	2212.000	1751.220	460.780
7	631.494	512.770	118.720
8	1001.283	748.920	252.360
9	869.857	694.300	175.560

For Table 5, V_{tot} is the total volume of material values occurring as a result of the blast (m³), and V_{add} is the volume (m³) of material values blasted as additional.

Equation 12 calculating the amount of material blasted additionally due to the effect of the shared blast hole influence at both end sides of the blast holes and the back region of the blast surface were developed. In this equation (see also Table 6), the length of the blast surface, the total burden of the blast end holes, bench height, the amount of explosive available in unit meter of the blast hole, and the uniaxial compressive strength of the rock have been included. During the equation development, the coefficients and exponential ranges were primarily defined, and then the most suitable formula was established using these determined coefficients and exponents. The solution for the amounts of the material blasted were able to be measured realistically using a computer software program as called Force 2.0.

$$Vadd = (15.c) + (9.H) + [3.(a+b)^2] + (3.Qb^2) - (9.\sigma) \tag{12}$$

Table 6. Data measured for blast tests

Test no	c (m)	H (m)	$a+b$ (m)	Qb (kg/m)	σ (Mpa)	V_{add} (m³)
			Arkavadi Quarry			
1	35.70	9.50	8.80	3.091		341.625
2	20.42	10.50	9.15	2.955		259.846
3	22.08	10.10	7.10	3.094		260.249
4	23.20	10.10	5.10	2.970	38.00	197.366
5	27.45	10.10	4.30	2.970		221.925
6	21.40	12.50	6.55	3.431		253.130
7	30.95	16.00	7.10	3.971		477.424
8	13.70	10.00	5.50	3.190		166.938
			Aravadi Quarry			
1	4.80	16.00	6.12	7.353		136.440
2	4.74	16.00	6.27	7.353		163.780
3	4.80	16.00	7.65	7.794	29.31	338.680
4	4.20	16.00	7.75	8.088		395.460
5	8.60	16.00	10.70	8.353		635.320
6	3.50	16.00	8.94	8.824		421.400
			Upper Aravadi Quarry			
1	8.80	12.35	6.80	4.154		184.320
2	9.40	12.00	5.70	3.000		249.250
3	27.50	12.60	8.45	3.286		775.720
4	25.20	11.80	6.00	2.928		257.520
5	8.35	12.00	5.35	3.071	20.33	159.020
6	23.95	12.00	6.20	3.000		460.780
7	7.65	12.00	5.30	2.714		118.720
8	9.70	12.20	6.45	3.357		252.360
9	10.50	11.90	6.80	3.357		175.560

For Table 6, a is the first burden, b is the second burden both in m; c is the total length of blasting surface in m; Qb is the average amount of explosive material of one meter in a blast hole in kg/m; σ is theaverage uniaxial compressive Strength in MPa;

Table 7 shows the volume of material values blasted additionally measured realistically and also calculated according to proposed equation.

A correlation of 77.17% was formed between material volumes blasted additionally calculated and measured according to the proposed equation (Figure 3).

Table 7. Material volumes blasted measured realistically and calculated according to proposed equation

Test no	Material volumes blasted as according to measured (m^3)	Material volumes blasted as according to proposed model (m^3)
	Arkavadi Quarry	
1	341.63	539.96
2	259.85	336.25
3	260.25	259.97
4	197.37	201.39
5	221.93	242.58
6	253.13	255.5
7	477.42	464.76
8	166.94	74.78
	Aravadi Quarry	
1	136.44	226.64
2	163.78	231.32
3	338.68	309.83
4	395.46	319.74
5	635.32	561.85
6	421.4	405.86
	Upper Aravadi Quarry	
1	184.32	250.57
2	249.25	190.5
3	775.72	768.71
4	257.52	434.98
5	159.02	164.42
6	460.78	426.6
7	118.72	146.08
8	252.36	231.01
9	175.56	254.22

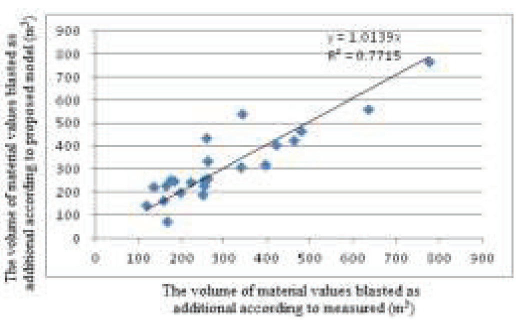

Fig. 3. Relationship between material volumes blasted additionally calculated and measured according to proposed equation. The equation calculating total material volume occurring as a result of blast can also be written as follows:

$$Vtot. = (B.S.H.m) + (15.c) + (9.H) + [3.(a+b)^2] + (3.Qb^2) - (9.\sigma), \tag{13}$$

Specific charge values have also been calculated by dividing the total explosive amount by the total the volume of material values which occurred as a result of the blast (Table 8). Table 8 gives the specific charge values calculated when not considering the length of the blasting surface and blast hole order number parameters. Table 8 also shows that although the total amount of explosives used in the blast operations were the same, considerable differences are evident between the specific charge values calculated by not considering the blast surface length and blast hole order number and the total volume of material formed as a result of blast. This difference becomes especially more apparent in the blast tests carried out in the Aravadi Limestone Quarry where the blast surface was kept shorter.

Table 8. Specific charge values calculated according to blast hole geometry and proposed calculated equation

Test no.	Q_{tot}	V_{geo}	V_{tot}	q_{geo}	q_{tot}
		Arkavadi Quary			
1	1043.75	1738.50	2278.46	0.602	0.458
2	662.50	1308.83	1645.08	0.506	0.403
3	637.50	1144.19	1404.16	0.558	0.454
4	370.00	726.28	927.67	0.510	0.399
5	561.25	973.54	1216.12	0.576	0.462
6	861.25	1186.45	1441.95	0.727	0.597
7	1362.50	1781.98	2246.74	0.765	0.606
8	407.50	690.62	765.4	0.589	0.532
		Aravadi Quarry			
1	251.25	470.00	696.64	0.532	0.361
2	251.25	474.74	706.06	0.527	0.356
3	268.75	587.52	897.35	0.451	0.299
4	276.25	520.80	840.54	0.528	0.329
5	426.88	870.24	1432.09	0.488	0.298
6	301.25	500.40	906.26	0.599	0.332
		Upper Aravadi Quarry			
1	328.75	700.19	950.76	0.470	0.346
2	254.38	637.58	828.08	0.399	0.307
3	937.50	2173.99	2942.7	0.431	0.319
4	761.25	1616.13	2051.11	0.471	0.371
5	304.38	627.75	792.17	0.485	0.384
6	761.25	1751.22	2177.82	0.435	0.350
7	228.75	512.77	658.85	0.446	0.347
8	329.38	748.92	979.93	0.440	0.336
9	329.38	694.30	948.52	0.474	0.347

For Table 8, Q_{tot} is the total amount of explosive material (kg), V_{geo} is the volume of material calculated using blast hole geometry in m^3 (kg/m), V_{tot} is the total volume (m^3) of material values occurring as a result of the blast, q_{geo} is the specific charge calculated using blast hole geometry (kg/m^3), and q_{tot} is the specific charge calculated using the total volume (kg/m^3) of material occurring as a result of a blast.

4. Results and conclusion

In this study, twenty-three blast tests were carried out at three different limestone quarries. The total volume of materials formed as a result of blast was reported by weighing after the blast. Samples were taken to a laboratory to determine physical and mechanical characteristics of the material.

It is important to know the amount of all materials formed as a result of blast before a blast occurs . Thus, the specific charge value must be calculated realistically, and it can be ensured that the equations determining the efficiency of any open quarry operations (according to the specific charge values) have correct results. Also, open quarry enterprises will be able to calculate beforehand the amount of the explosive according to their production capacity. This is a simple way to reduce costs associated with blasting.

Discontinuity characteristics of the blast surface remained as constant values according to the discontinuity classification system of Lilly (1986) in each blast test. Therefore, these values have not been used in the calculations. Discontinuity ranges per fissure formed at sizes smaller than 50 cm, and the angle of the discontinuity plane also remained inside the blasting surface. Lateral sections of blast end holes were planar in design for all the blast tests.

The volume of material values blasted additionally due to the length of blast surface and the order number of the blast holes except for the amount of material calculated according to blast hole geometry (average burden × average spacing × average bench height × the number of holes) were calculated realistically, and an equation estimating these values was created. The new equation included the parameters of the length of the blast surface, the blast hole order number (the amount of burden on both end holes of the blasting surface), the bench height, uniaxial compressive strength of the rock, and the amount of explosive found in one meter of the blast hole (blast hole diameter effect). A correlation of 77.17% was formed between the volume of material blasted additionally calculated and the proposed equation (Figure 3). Thus, the total amount of materials formed as a result of blast was calculated by adding the amount of material calculated according to blast hole geometry to the amounts of material blasted additionally, calculated according to proposed equation. Specific charge values were also calculated for each blast test by dividing the total explosive amounts by the total material volume totals formed after the blast.

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تقدير قيمة الشحنة المحددة قبل حدوث عملية التفجير

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ملخص

يوضح هذا البحث أنه طبقا للكتابات السابقة توجد عدة معادلات لتقدير قيمة الشحنة المحددة قبل حدوث عملية التفجير، ووفقاً لهذه القيمة ،تم تطوير بعض المعادلات التي تقوم بتقدير كفاءة ماكينة التحميل وآلة التكسير 'الكسارة'(.ويشير هذا البحث إلى أنه من الضروري حساب قيمة الشحنة المحددة بشكل واضح قبل عملية التفجير لتقدم هذه المعادلات المطورة نتائج صحيحة. يؤثر طول سطح الانفجار وترتيب مكان حفرة التفجير علي قيمة الشحنة المحددة الي حد كبير (Tosun et al.، 2013)، وتوضح الدراسة انه تم إجراء عدد محدد من اختبارات التفجير علي ثلاثة محاجر مختلفة للحجر الجيري حيث تم تطوير معادلة تقدر قيمة الشحنة المحددة قبل حدوث التفجير وذلك باستخدام معاملات مثل طول سطح الانفجار، وترتيب مكان حفرة التفجير (مقدار حمولة طرفي حفرة سطح الانفجار) ، وارتفاع المنصة، وقوة الضغط أحادي المحور للصخرة، وكذلك كمية المتفجرات الموجودة في المتر الواحد في حفرة التفجير.