Influence of Number of Blows and Water Content onE Engineering Properties of Compacted gypseous Soi

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الخلاصة

ان المشكلة الرئيسية في إعادة تمثيل التربة الجبسية مختبرياً تعود إلى كون الجبس يعمل كمادة رابطة بين جزيئات التربة مما يمنح التربة الجبسية تماسكاً قوياً. إلا ان هذه الرابطة تنكسر ويكون من الصعب إعادتها إلى وضعها الحقيقي عند إعادة رص التربة بالطرق الاعتيادية حيث تنخفض قيمتي التماسك وزاوية الاحتكاك الداخلي للنماذج المعاد رصها بشكل واضح عن قيمها الحقلية. لذلك تم اقتراح دراسة إمكانية إعادة نمذجة التربة الجبسية ومحاولة معرفة مدى تأثير عدد الضربات لكل طبقة رص وتأثير قيمة المحتوى الرطوبي على قيمة كل من التماسك وزاوية الاحتكاك الداخلي من اجل تسهيل اعادة نمذجة التربة الجبسية مختبرياً ومحاكاة تصرفها حقلياً. تم اجراء فحص الحدل على التربة بعدد ضربات (30,25,15) ضربة لكل طبقة حدل ولقيم مختلفة للمحتوى الرطوبي لكل حالة لمعرفة تأثير عدد الضربات لكل طبقة حدل وكذلك معرفة تأثير المحتوى الرطوبي على قيمتي التماسك وزاوية الاحتكاك الداخلي للتربة. تم استخدام ثلاث قيم مختلفة من المحتوى ألجبسي (18.9, 60%) حيث اخذت من ثلاث اماكن مختلفة في مدينة تكريت والواقعة في محافظة صلاح الدين وسط العراق . وتم التوصل في هذا البحث الى ان الزيادة في عدد الضربات والمحتوى الرطوبي تؤدي الى زيادة كل من قيمتي التماسك وزاوية الاحتكاك الداخلي. كما أن العدد الأمثل للضربات كان (30) ضربة لثلاث نسب مختلفة من المحتوى ألجبسي ولكن المحتوى الرطوبي الأمثل يزداد بزيادة نسبة الجبس حيث كان (7, 12, 15) ٪ لثلاث نسب جبس مختلفة (18.9, 32.4, 60)٪ بالتتابع من اجل إعادة قولبة التربة المستخدمة في البحث. لذا يمكن القول ان تغيير نسبة الجبس في التربة لم يؤثر تأثيراً واضحاً على عدد الضربات الأمثل ولكن زيادة نسبة الجبس أدت إلى زيادة ملحوظة في المحتوى الرطوبي الأمثل لإعادة القولبة..

الكلمات المفتاحية

التربة الجبسية، إعادة النمذجة مختبريا، عدد الضربات، المحتوى الرطوبي.

Abstract

The main problem in laboratory re-molded gypseous soil is that, gypsum material in soil do as bounded material between soil particles which increases soil strength. But these bounding between soil particles would be broken when attempts to re-compact soil and made it difficult to return to its origin state. As a results, the value of cohesion and angle of internal friction would be changed for samples which that re-compacted using the ordinary compaction method comparing with the field values. In this study, compaction test was used with different blows number (15, 25, 30) for each layer. Different value of water content are used for each case to record the effect of numbers of blows and water content on thecohesion and angle of internal friction. Three different gypsum content samples (18.9%, 32.4%, 60%) are used in this study which taken from three different locations in Tikrit city - Salah-Aldeen Governorate, in the middle of Iraq. The results of laboratory tests for re-molded gypseous soil show that increasing number of blows and water content leads to increase cohesion and angle of internal friction. Also, the optimum blows number per layer was (30) for the three percent of gypsum content. But the optimum water content increased with increasing gypsum content to (7%, 12%, 15%) for the three values of gypsum content (18.9%, 32.4%, 60%) respectively, to obtain laboratory value of cohesion and angle of internal friction close to the field value. So it could be notice that, changing gypsum content in soil had no effect on the optimum number of blow for laboratory re-molded gypseous soil. But increasing gypsum content leads to increase optimum water content.

Keywords

Gypseous Soil, Laboratory Re-Sampling, Number of Blows, Water Content

1. Introduction

Gypseous soil is that soil which contains enough gypsum($CaSO_4.2H_2O$) which effected onengineering construction. I t is the worst among the problematic soils as it contains soluble salt and its chemical reactions. Gypseous soil in Iraq covers (11 to 15) % of the area of Iraq [1].

One of the most complicatedengineering problems isthe presence of gypsum in the soils due to its detrimental behavior, especially when accompanied by environmental changes in temperature, water content and presence of certain types of salts. Therefore, some teqniques are needed to improve these soils before constructing on it [2].

Many studies have been made to investigate the effect of gypsum content on the physical and mechanical properties of gypseous soils. These soils arecharacterized by high void ratios and low dry densities. Accor dingly, upon wetting gypseous soil is renowned for being highly compressible material with low bearingcapacity and hence considered among the poorest of foundation material [3,4].

In the last decades many attempts have been made to understand the behavior of these soils. Most of these attempts were laboratory and field investigations. Obtaining undisturbed samples of gypseous soils is in many cases very difficult. This leds many researchers to prepare the gypseous soils in the laboratory. The behavior of gypseous soils in the laboratory is highly complicated and different behaviors were noted. This caused a conflict in understanding the phenomena related to the gypseous soils [5].

Compaction is one of the methods are used to improve the engineering properties of the soil mass which occurs through increasing strength, reducing compressibility, volume change and permeability, and increasing the stability of structures [6,7].

This study deals with the effect of number of compaction blows (N) and water content (w c) on the engineering properties of gepyseous soil that re-compacted in the laboratory specially (c) and (φ) for different values of gypsum content.

2. Experimental Work:

2.1. Sampling:

Three types of natural gypsuous soils taken from three different locations in Tikrit city - Salah-Aldeen Governorate, in the middle of Iraqwhich used in this study . Samples (S1), (S2) and (S3) with three different values of gypsum content (18.9%, 32.4%, 60%) respectively, were taken from depth of (1.5-2) m below the natural ground surface. Two types of samples, disturbed and undisturbed packed and transported to the soil mechanics laboratory, Civil Eng. Dept., College of Engineering, Tikrit University. Samples prepared for the testing program and tested according to the American Society for Testing and Materials Specifications (ASTM) [8] and British Standards (BS) [9].

2.2. Laboratory Testing Program:

2.2.1. Classification and Engineering Tests:

The grain size distribution for the three soils (distributed sample) are shown in Fig. (1). Also the physical and chemical properties are shown in Tables (1) and (2).

Table (1): Physical properties of the soils

Property	S1	S2	S3
Natural Water Content (wc)%	5.7	4.3	2.9
Specific Gravity	2.35	2.64	2.42
Liquid Limit (L.L)	28	24	N.L
Plastic Limit (P.L)	N.P	N.P	N.P
Plasticity Index (P.I)	N.P	N.P	N.P
Dry Unit Weight(γ_d) kN/m^3	13.8	14	14.8

Table (2): Chemical properties of the soils

Property	S1	S2	S3
PH	8.9	7.4	8.1
Gypsum Content (Gyp.)%	18.9	32.4	60
Total Soulble Salt (T.S.S)%	32.7	38	67.4

The three soils were classified as poorly graded sand (SP) according to the Unified Soil Classification System (USCS). The angle of internal friction (φ) and apparent cohesion (c) for undisturbed sample taken from the field-shown in Table (3) and for disturbed samples shown in Tables (4), (5) and (6). Direct shear test were conducted according to the ASTM (D3080-72) [10], under normal pressures of 50, 100 and 200kPato determine the shear strength parameters cohesion and angle of internal friction.

A calibrated proving ring at (2.5kN) capacity and (2mm) precision dial gage, for vertical deformation (0.01 mm) precision dial gage was used while for horizontal deformation (0.01 mm) dial gage was used. The rate of strain was (0.6 mm/min). The shear stress and vertical displacement were plotted against horizontal displacement for each test. From which, the shear stress versus normal stress was obtained and the strength parameters, the cohesion intercept (c) and the angle of internal friction (φ) determined.

Table (3): Engineering properties of the soils

Property	S1	S2	S3
Apparent Cohesion (c) kN/m2	29	39	54.1
Angle of Internal Friction (ϕº)	24.6	40	30.7

2.2.2. Re-mouded of Gypseous Soil:

The main problem in laboratory re-molded gypseous soil is a great difference in field and laboratory values of both (c) and (φ). The gypsum works as a binding agent between soil particles. Therefore, it has a significant effect on the cohesion and strength of gypseous soil. In case of refraction this binding and try to re-compaction soil in the laboratory, the distribution of gypsum in soil would be differ and would not works as a binding agent to soil particles which leading to a significant reduction in laboratory value of (c) and (φ). So, it is important to study the possibility of re-molded gypseous soil tofind how many blows numbers per layer (N) and water content (w c) values effected on (c) and (φ), reach to the field values of (c) and (φ) and to facilitate the formation models in laboratory studies and scientific research to simulate the disposal field gypseous soil. In this study, compaction test for disturbing soil samples with number of blows(N) (15, 25, 30) for each layer and different values of water content (w c) are prepared. Then re-molded soil ret urn to the value of its field moisture by drying it with percent of error not exceed (3%). Compaction test was performed for each case in order to investigate the effect different number of blows and water content on the fundamental characteristics of soil.

2.2.3 Compaction Test:

Compaction tests are carried out for the gypseous soil to determine the moisture-unit weight relationship. Samples are compacted in three equal layers each hammered by (15, 25, 30) blows using (2.5) kg hammer dropped from (30.5) mm height. These samples are compacted in a mold of(101.6) mm in diameter and (115.5)mm in height.

3. Results and Discussion:

3.1 Effect of Number of Blows:

The effect of number of blows (N) on engineering properties of gypseous soil (c, φ) was investigated. Number of blows (15, 25, 30) per layer for each value of water content (wc) with three percent of gypsum content (18.9%, 32.4%, 60%) were studied and the results are shown in Tables (4), (5) and (6).

Table (4): Engineering properties for re-representation soil (gypsum content 18.9%)

Water Content (%)	Number ofBlows (N)	c (kN/m2)	φ (deg)	γd (kN/m3)
7	15	16	20.3	13.1
7	25	21	22	13.4
7	30	27.4	26.2	13.5
10	15	19	26	13.8
10	25	24	27	14
10	30	33	35	14.6
12	15	20.4	29.2	12.9
12	25	28.6	30.1	13.2
12	30	35.4	39.6	14.0

Table (5): Engineering properties for re-representation soil (gypsum content 32.4%)

(%) Water Content	(Number of Blows (N	(c (kN/m2	(ϕ (deg	(γd (kN/m3
10	15	21	27.2	11.1
10	25	27.2	32.5	12.2
10	30	34.1	36.86	13.0
12	15	26.3	32.8	13.4
12	25	33.5	37.62	13.85
12	30	40.3	41.8	14.3
15	15	32.52	37.04	12.12
15	25	38.7	42.27	13.3
15	30	44.69	43.97	14.0

Table (6): Engineering properties for re-representation soil (gypsum content 60%)

(%) Water Content	(Number of Blows (N	(c (kN/m2	(ϕ (deg	(γd (kN/m3
12	15	32	14	11.7
12	25	40	15	12.4

12	30	45	20	13.0
15	15	40	18	12.9
15	25	50	23	14.0
15	30	52.7	28.8	14.7
17	15	42	20.3	13.0
17	25	51	26.4	14.3
17	30	54	31.7	15.0

3.1.1. Effect of number of blows on the cohesion of gypseous soil:

The results show that the cohesion of gypseous soil (c) increased with increasing the number of blows for each value of water content (wc) and gypsum content as shown in Figs. (2), (3) and (4) due to increasing convergence between soil particle with increasing number of blows. Also there was a significant increasing in cohesion (c) with increasing water content (w c) by remaining numbers of blows (N) constant due to increasing binding agent between gypsum and soil particle when it reaches to optimum moisture content which was (7%, 12%, 15%) for the three percent of gypsum content (18.9%, 32.4%, 60%) respectively. But this increasing in cohesion (c) would be disappear when excessiveincreasing in water content (wc) occurs because soil particle would be diverging and sliding each other. Also gypsum would be dissolving which led to decreasing binding agent between soil particle and decreasing the cohesion of the gypseous soil (c).

3.1.2. Effect of number of blows on the angle of internal friction of gypseous soil:

The results show that the angle of internal friction (φ) of the gypseous soil increased with increasing the number of blows for each value of water content (wc) and gypsum content as shown in Figs. (5), (6) and (7) due to increasing convergence between soil particle with increasing number of blows. Also there was a significant increasing in value of (φ) with increasing water content (wc) by remaining the value of (N) constant due to increasing binding agent between gypsum and soil particle when it reaches to optimum moisture content which was (7%, 12%, 15%) for the three percent of gypsum content (18.9%, 32.4%, 60%) respectively. But this increasing in angle of internal friction (φ) would be disappear when excessive increasing in water content (wc) occurs because soil particle would be diverging and sliding each other. Also amount of gypsum would be dissolving which led to decreasing binding agent between soil particle and decreasing the angle of internal friction (φ).

3.2. Optimum number of blow (n) and water content (wc) for re-moldedgypseous soil:

As it clear from the previous figures which describe relationship between number of blows (N) for different value of water content (wc) with each of cohesion (c) and angle of internal friction (φ) that, the optimum number of blows (N) for each layer was (30) for different values of gypsum content. But the optimum values of water content (w c) differed with each value of gypsum content. It was (7%) when the gypsum content (18.9%), (12%) when the gypsum content (32.4%) and (15%) when the gypsum content (60%) due to the convergence of laboratory values of (c, φ) with the field values. Hence, these values of number of blows (N) which was (30) blows and water content (w c) which was (7%, 12%, 15%) for the three percent of gypsum content (18.9%, 32.4%, 60%) respectively was the best value for laboratory re-representation gypseous soil. Also, the value of (γ d) was maintained to remain within the range of its field value during re-representation gypsum soil as shown in Figs. (8), (9) and (10) due to the effect of (γd) on the engineering properties of re-representation soil.

3.3. Effect of gypsum content on optimum number of blows (n) and water content (w c):

Figs. (11) and (12) show the effect of gypsum content on each optimum number of blows (N) and optimum water content (w c). As it clear from these figures, the optimum value of number of blows (N) was (30) for the three percent of gypsum content. But optimum percent of water content (w c) increases with increasing gypsum content. From that, it could bededuced that the number of blows is working on reconnecting power ionic between molecules gypsum, so the optimal number of blows remains constant with different values of gypsum content. While the value of the moisture content optimal, increases with the proportion of gypsum, because increasing the proportion of gypsum need to more amount of water to re-melt salts and configured to re-link with soil particles.

4. Conclusion:

In re-molding gypseous soil, increasing number of blow (N) leads to increase cohesion of the soil (c) and angle of internal friction (φ) within optimum limits of number of blow (N).

In re-molding gypseous soil, increasing water content (wc) leads to increase cohesion (c) and angle of internal friction (φ) of the soil within optimum limits of water content (wc). In other words, when water content (wc) exceeds optimum percent, this would be lead to collapse of infrastructure and melting association gypsum between soil particle.

In re-molding gypseous soil, increasing gypsum content had no effect on optimum numbers of blows (N) which was (30) blow per layer, but optimum water content increases with increasing gypsum content.

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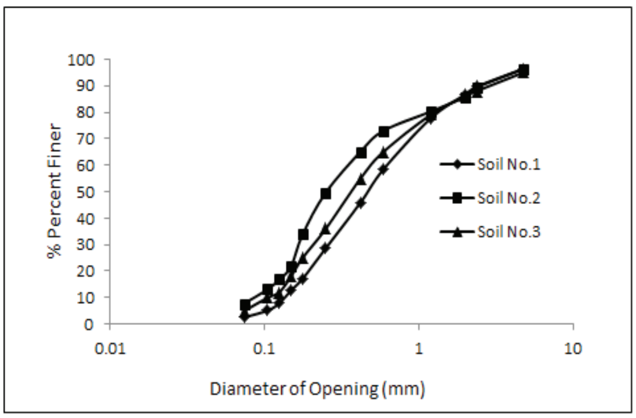

Fig. (1): Grain size distribution for the soils

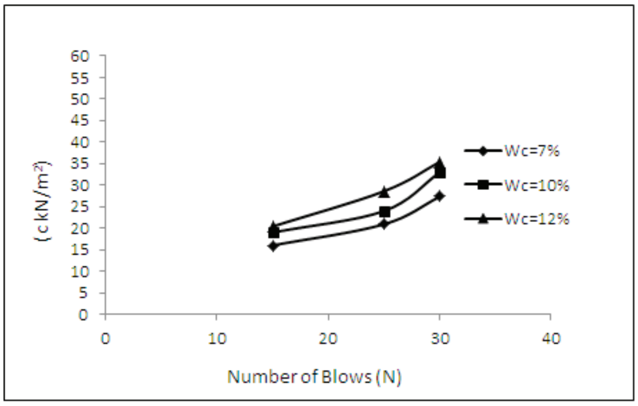

Fig. (2): Effect of number of blows (N) on the cohesion (gypsum content 18.9%)

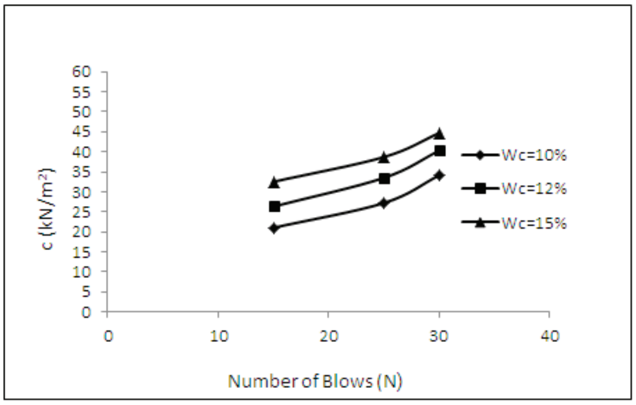

Fig. (3): Effect of number of blows (N) on the cohesion (gypsum content 32.4%)

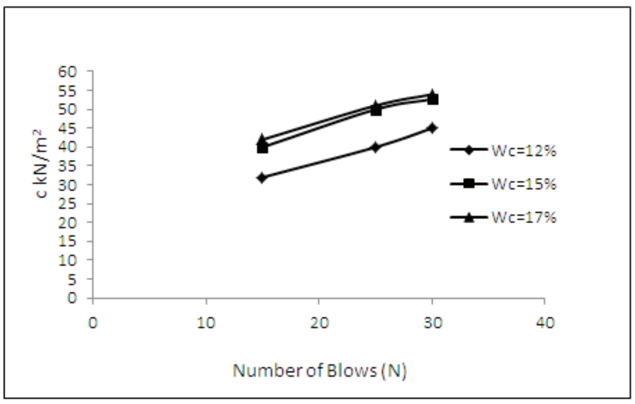

Fig. (4): Effect of number of blows (N) on the cohesion (gypsum content 60%)

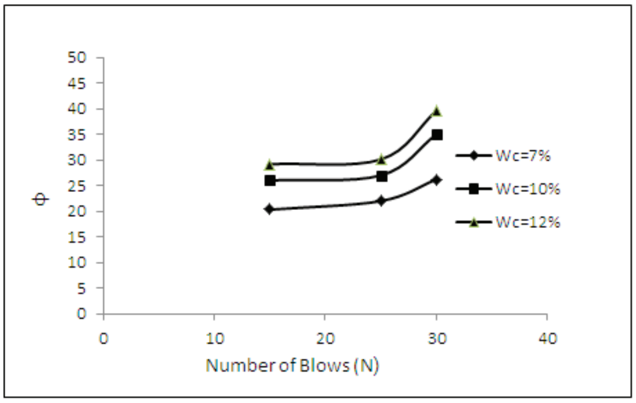

Fig. (5): Effect of number of blows (N) on the angle of internal friction (gypsum content 18.9%)

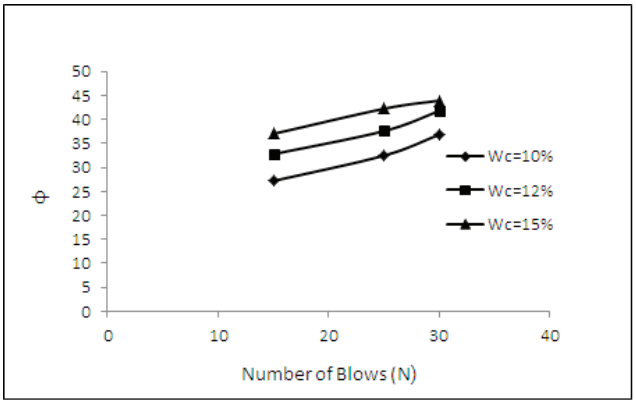

Fig. (6): Effect of number of blows (N) on the angle of internal friction (gypsum content 32.4%)

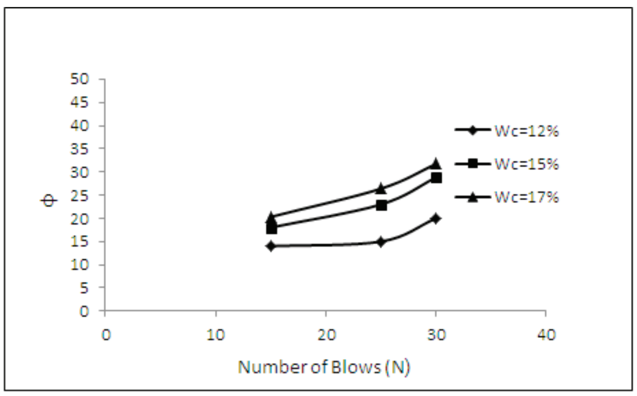

Fig. (7): Effect of number of blows (N) on the angle of internal friction (gypsum content 60%)

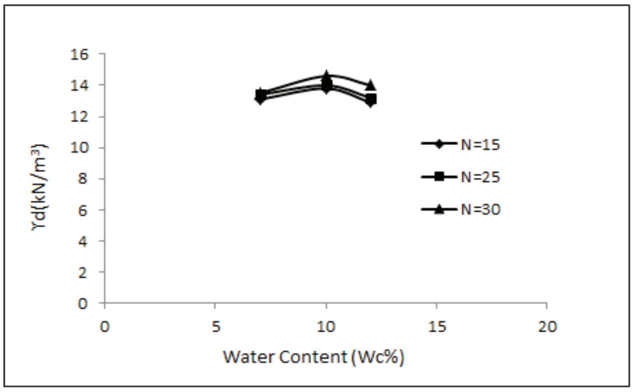

Fig. (8): Water content and dry density relationship (gypsum content 18.9%)

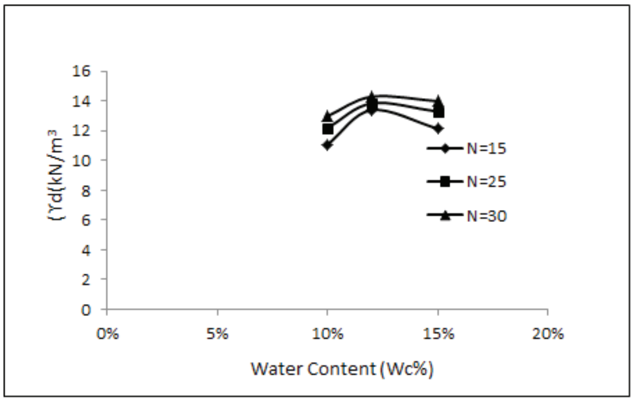

Fig. (9): Water content and dry density relationship (gypsum content 32.4%)

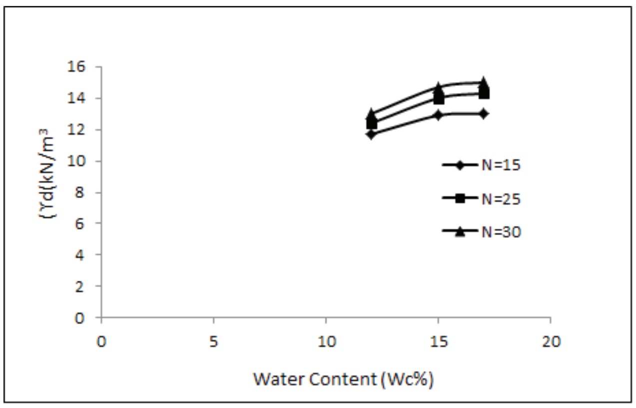

Fig. (10): Water content and dry density relationship (gypsum content 60%)

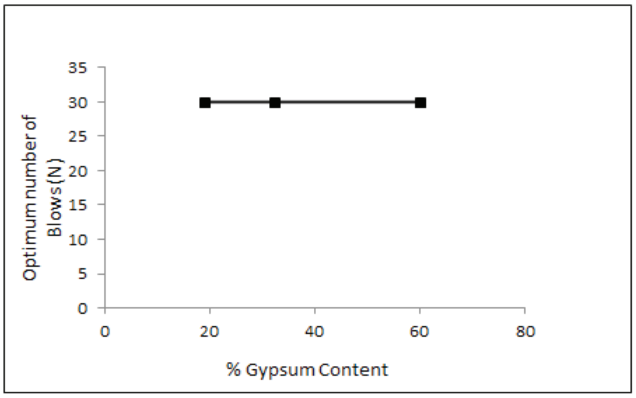

Fig. (11): Effect of gypsum content on optimum number of blows (N)

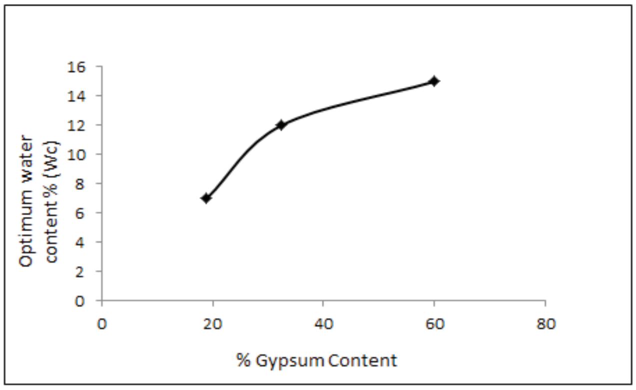

Fig. (12): Effect of gypsum content on optimum water content (wc)