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A MODIFIED COLLAPSE TEST FOR GYPSEOUS SOILS

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ABSTRACT:- Gypseous soil is one of soils which presents a risk for engineering structures, specially with high contamination of gypsum, because of the problem of collapse of soil under the footings, during soaking of these soils with water from any source. There is another problem causes by leaching process and the continuous dissolution of the residual undissolved gypsum inside the soil skeleton (A. Awn 2004), which creates cavities below hydraulic structures and irrigation channels and reduce the bearing capacity of soil below these heavy structures. It arises during the last two decades, the need for more practical and easier method to measure the collapsibility in the laboratory and field, since more than 10% of the total Iraqi area was gypseous soil and contain 15% to 70% gypsum.

During the last two decades the need was appear for constructing a new practical device to measure the collapsibility during the soaking or leaching test, which is easier than the conventional single or double odometer test (Jennings, J.E. and Knight, K. 1957), (Knight K. 1963). This modified device which is designed and constructed locally, was effective to measuring the collapsibility at field and laboratory in addition to the ability to measure the compressibility at long time leaching for these types of problematic soil.

A model test includes a cylindrical plastic container with 45cm diameter and 500cm height open from top to fix a water control system for fixing the head of water. An artificial gypseferous soil was prepared with (70%, 60%, 50%, 40% and 30% gypsum) was placed inside the container with 17.3kN/m3 density. A standards circular shaft applied 100kPa stress was applied at all stages of tests.

The results of model tests and the new device used in this study shows a simple, high activity in measuring the collapsibility, in addition to the ability to measure the compressibility of such soil at leaching process, at the same time.

***Keywords*:-** gypseous soil, collapsibility, field test.

EXPERIMENTAL WORK

The Modified Device

A stainless steel device was designed and constructed locally with the assistance of professionals. It is consists of a stainless steel shaft work as a piston, and a hollow steel holder stiffened at the base to ensure stability of the hole system. A steel vertical holder was welded to circular steel base of instrument. The piston was made from stainless steel iron with 20mm interior diameter, as shown in figure (2-a). A holder was welded to the upper side of piston to control the strain in the soil model, with the aid of dialgauge. A hole was made in circular steel base of the device for feeding water in soaking test. a circular weights holder welded to the steel shaft at the middle portion, if additional weights is needed, in order to increase stress level, which reaches more than 2000kPa, The device was designed and constructed locally as shown in figure(2-b).

The laboratory collapse test consists of placing the new collapsibility device over a container which is filled with gypsiferous soil with 17.3 kPa density, as shown in figure (2-c). The mechanism of the device was checked before test. The container was opened from the top, to ensure continuous feeding the sample with water. Holes was made at the bottom of container and a filter material made of aggregate was placed at the bottom of container to ensure not to lose particles during leaching test of gypseous soil if needed for leaching test.

SOIL PREPARATION AND TEST METHODOLOGY

The soil used in this study was artificially made in laboratory (gypsiferious soil) to make good category about the behavior of this soil using this new device. Firstly the soil was oven dried, mixed thoroughly with gypsum 70%, to ensure fix boundary conditions for all samples. A filter material made from graded aggregate was placed at the last 25mm bed of container. The soil was places in to container with three layers. Each layer was compacted to the required height, leveled with a sharp edge steel road. The collapse device was prepared by placing the steel shaft inside the hollow holder with ensuring free movement of the system. The bottom of shaft was touching the soil surface. The dialgauge was fitted at its position and the first reading was recorded after 30 minutes presenting the immediate settlement of the shaft under its own weight which applies 100kPa stress at the center of soil specimen. The soaking test started when feeding water inside soil sample from the upper water control system from top to bottom. The dial reading which is presenting the

collapsibility is recorded with time until 7 days. The leaching test started at the end of soaking test by opening the drainage valves at the bottom of container and starting draining the saturated gypsiferious soil with continuous feeding of the specimen with water. The dial reading was recorded from starting leaching until a month.

RESULTS AND DISCUSSION

Figures(3)to(8) shows the collapse potential in terms of S/B% which represent the ratio of settlement to width of footing is the indication of collapse potential with different gypsum content(30, 40, 50, 60 and 70%) tested at the same initial conditions(soil density=17.3kN/m3,stress level=100kPa).

This new device which manufactured locally with special skill, was successfully gave a simple and faster collapse test upon soaking gypseous soil with water, compared with the ordinary single oedometer collapse test, using consolidation cell, as mentioned before.

The modified collapse test (MCT) device can also be used in field as an insitue test for collapsibility measurement, as for SPT test or Plate Loading Test. The main advantage of this insitue test device that it is not requiring obtaining undisturbed or disturbed samples as in the ordinary consolidation test (single or double oedometer test for gypseous soil). Also this device is not requiring any additional equipment in test. Also it give us an indication about gypsum content for gypsiferous soil at any depth below ground level by making a hole to the required depth by any method of boring, and placing the device at that depth with soaking the soil below the shaft with water. The results has to be compared with the ordinary single oedometer for a sample tested at the same conditions(soil density, collapse stress, initial moisture content, initial temperature) to give a correlation between the two devices.

Figure (9) shows a bar chart diagram for the deformation ratio S/B% at the end of collapse due to soaking test for soils with different gypsum content tested at soaking stress=100kPa.

COMPARISON WITH OTHER DEVICES

Figure (10) shows the relation between strain and stress for gypiferous soil sample with gypsum content=30%. The upper curve is for dry sample while the lower curve is for

sample soaked with water using the ordinary oedometer test device. This is what we call double oedometer test to find the collapsibility in a specific stress level.

Figure(11): shows the comparison between the results obtained from the modified collapse test device proposed in this study and the ordinary double oedometer test result for gypsiferous soil sample using the same soil conditions (gypsum content=30%) and tested at the same stress level=100kPa.

CONCLUSIONS

Collapsibility is one of the important parameters that define gypseous soil. It is measured using the ordinary Odometer Test device (Single or Double Odometer Test) proposed by (Jenings, J. E. and Knight, K. 1975).

Ordinary Odometer test device need special skill in preparing the testing cell, settings and mechanical parts. The soil sample prepared either by taking undisturbed or disturbed soil from Shelby tube. The difficulty was also in preparation, settings and method of test either by single or double odometer test, compared with that in the Modified instrument proposed in this study which is simpler in preparing laboratory model sample and testing methodology.

The size of the modified test sample is larger than that for the soil sample in the ordinary odometer test. Which is more close to the natural full scale presentation?

This modified instrument can be standardized to give an indication of gypsum content and limit values of gypsum content in soil.

This Modified device is also proposed for leaching test in addition to soaking test if needed, which is more effective than the ordinary odometer collapse test device

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Fig. (1): Structural failure for light weight buildings constructed on collapsible gypseous soil.

Fig.(2-a): Manufacturing steps of the Modified Collapse Test Device (MCT), proposed in this study.

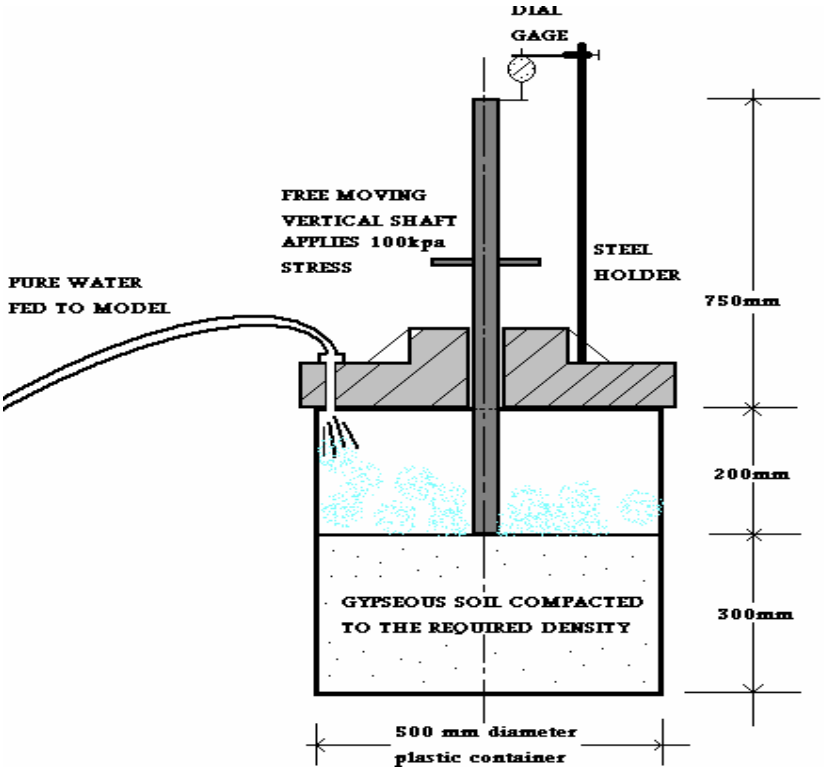

Fig. (2-b): parts and mechanism of (MCT) proposed in this study.

Fig.(2-c): Setting of MCT instrument over the model test sample containing gypsiferous soil, for laboratory model collapse test.

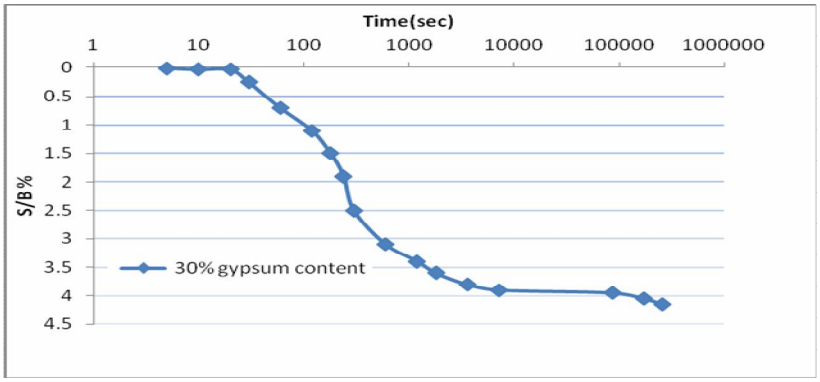

Fig (3): Collapse for soil with 30% gypsum content using the new device for collapse test.(soaking stress=100kPa, soil density=17.3kN/m3).

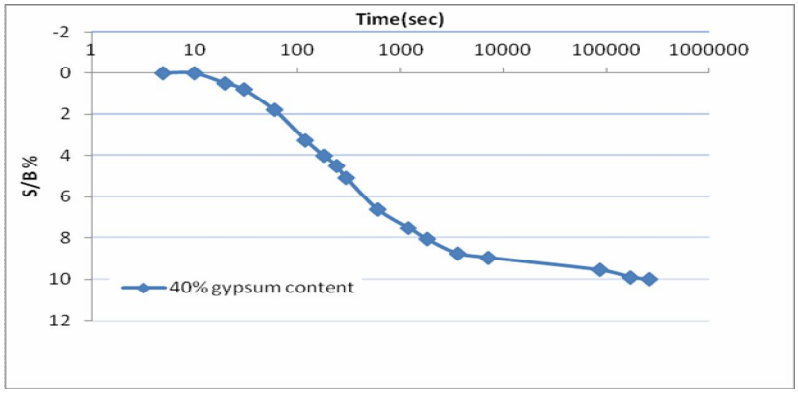

Fig (4): Collapse for soil with 40% gypsum content using the new device for collapse test.(soaking stress=100kPa, soil density=17.3kN/m3).

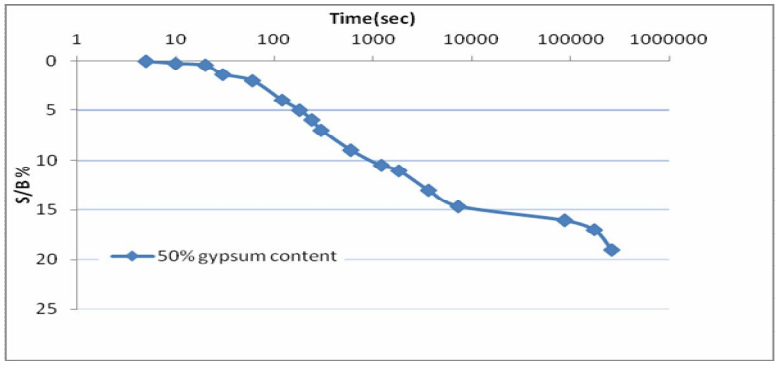

Fig (5): Collapse for soil with 50% gypsum content using the new device for collapse test.(soaking stress=100kPa, soil density=17.3kN/m3).

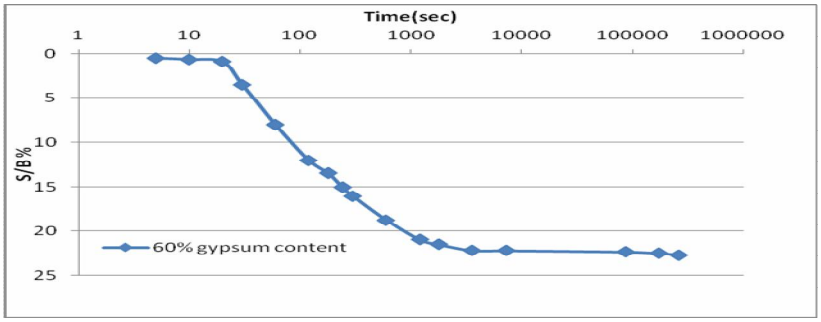

Fig (6): Collapse for soil model with 60% gypsum content using the new device for collapse test.(soaking stress=100kPa, soil density=17.3kN/m3).

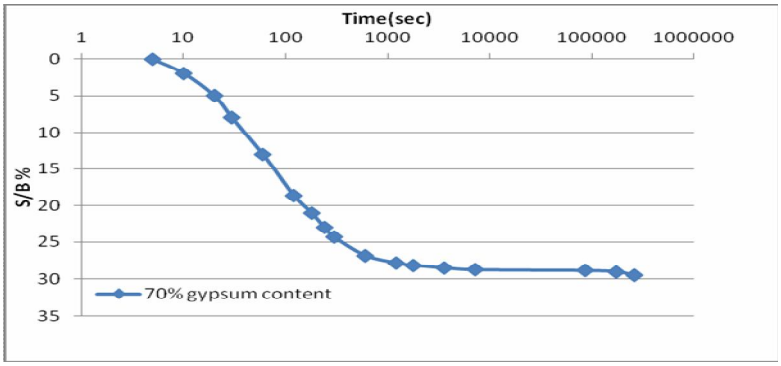

Fig (7): Collapse for soil model with 70% gypsum content using the new device for collapse test.(soaking stress=100kPa, soil density=17.3kN/m3).

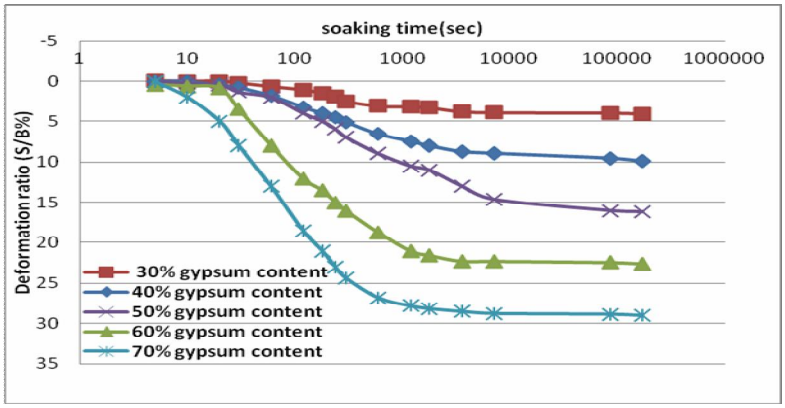

Fig (8): Results of laboratory test on model samples to semulate the collapsibility of gypseous soil with different gypsum content using MCT device.(stress level=100kPa, soil density=17.3kN/m^3).

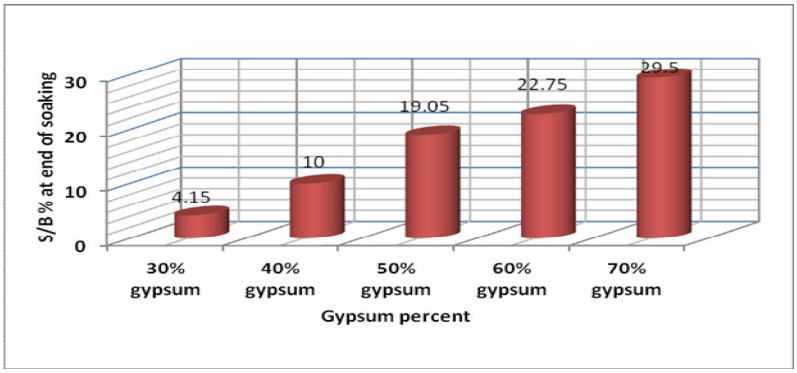

Fig (9): Deformation ratio S/B% for soils with different gypsum content tested by the MCT device.(stress level=100kPa, soil density=17.3kN/m^3).

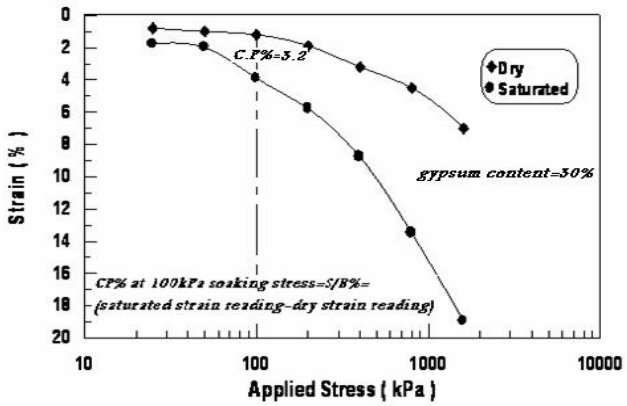

Fig.(10): Double odometer collapse test proposed by for (Jennings, J.E. and Knight, K. 1975) for the used soil with gypsum content=30%.

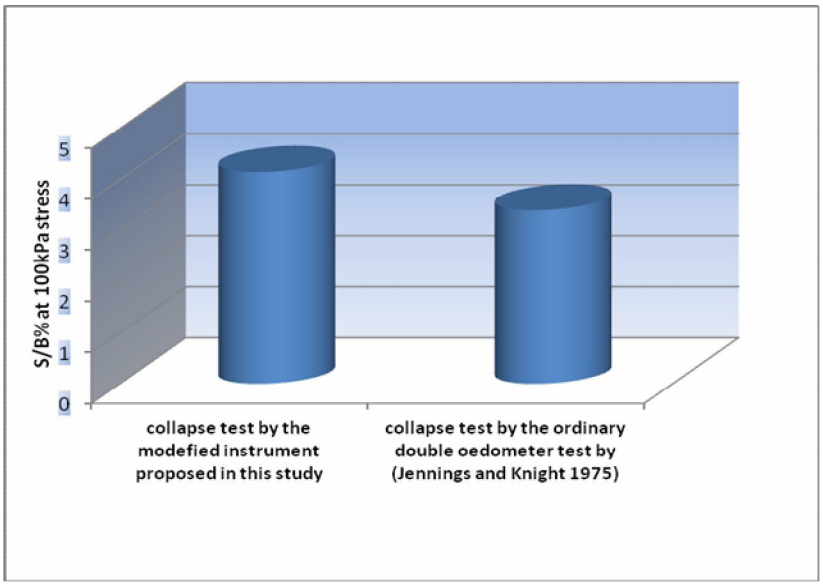

Fig (11): Collapse measuring using the MCT device proposed in this study, compared with that measured using the ordinary double oedometer collapse test, proposed by Jenings, J.E. and Knight, K. 1975) in measuring collapsibility of gypseous soil.(G.C=30%, soaking stress=100kPa).

جهاز مطور لقياس انهيارية الترب الجبسية

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الخلاصة

تعد الترب الجبسيه من انواع الترب التي تشكل خطرا على المنشات الهندسيه والهايدروليكيه لما تتسببه من انهياريه عاليه للتربه ذات المحتوى الجبسي العالي والموجوده تحت الاساس وبالتالي تؤدي الى فشل المنشا الانشائي بسبب الهبوط التباييني او الانهيار الكامل للمنشا اثناء غمر التربه بالماء. هنالك مشكله اخرى لهذه الترب تتمثل بالهبوط البطئ الذي يتزامن مع عملية غسل التربه الجبسيه وما يرافقه من استمرار في ذوبان ما تبقى من هذه الماده داخل التربه وتكّون فجوات تحت المنشات الهايدروليكيه و قنوات الري مما يضعف قابلية تحمل التربه تحت هذه المنشات الثقيله وبالتالي حدوث انهيار للمنشا باكمله. لذلك هنالك ضروره ملحه لايجاد مقياس لانهياريه التربه الجبسيه بصوره دقيقه و سريعه, نضرا لازدياد حركة الاعمار والبناء ولما تشكله التربه الجبسيه من نسبه كبيره من المساحه الكليه للاراضي العراقيه (تصل اكثر من20%).

خلال العقدين الماضيين دعت الحاجه لايجاد طريقه اسهل واسرع لايجاد انهيارية التربه الجبسيه مختبريا و موقعيا لفحصي الاغمار والغسل في ان واحد بدل الطرق التقليديه المعقده وغير الدقيقه والتي تشمل فحص الاغمار فقط باستعمال خلية النضمام (طريقة نايت, 1963).

تم في هذه الدراسه تصنيع جهاز قياسي وعملي لفحص انهيارية التربه الجبسيه حقليا ومختبريا في حالة اغمار للتربه الجبسيه, اضافة الى امكانية اجراء فحص الانضغاطيه لهذه الترب اثناء عملية الغسل, وهو ما يميز هذا الجهاز عن الجهاز التقليدي لفحص الانهياريه فقط بخلية الاثضمام وما يتطلبه من تحضير للنموذج وتعقيدات الفحص من انسداد الحجر المسامي واضافة الاوزان لتسليط الاجهاد المطلوب على خلية الانضمام.

تم استعمال نموذج مختبري يتالف من اسطوانه بلاستيكيه سميكه بابعاد 45 سنتمتر قطر و 50سنتمتر ارتفاع, مثقوبه من الاعلى لتثبيت منظم ميكانيكي لانسيابية دخول الماء الى داخل النموذج. تم استعمال تربه جبسيه تم تحضيرها مختبريا بنسب مختلفه من الجبس(30%,40%, 50%,60%,70%) تم وضعها داخل الموديل المختبري بكثافة رص 17.3كيلو نيوتن/متر مكعب. تم تسليط ضغط عمودي ثابت من خلال عمود الجهاز القياسي الذي ثبت طوال فترة فحص النماذج لتسليط اجهاد ثابت مقداره 100 كيلو باسكال.

اظهرت الفحوصات التي اجريت على النماذج فاعلية الجهاز في قياس الانهياريه بصوره دقيقه اضافة الى قدرته لقياس الانضغاطيه اثناء عملية الغمر المستمر لهذه التربه, كما وتم مقارنة نتائجة مع الجهاز التقليدي بواسطة خلية الانضمام واثبت فعاليته. فهو يتميز عن باقي الاجهزه التقليديه بسهوله استعماله وشموليته لفحصي الغمر والغسل في ان واحد وهو ما يميزه عن الاجهزه التقليديه الاخرى. اضافة الى امكانية تطوير اجزاءه بما يتناسب ونوع التربه والفحص المطلوب.

كلمات الدالة: التربه الجبسيه, انهياريه, الفحوصات الحقليه.