IMPLEMENTATION AND TREATMENT OF CEMENT GROUT MIXTURE FOR UNDERGROUND CAVITIES

[1]G.Pranay Kumar , [2]G.Manoj Kumar, [3]V.Sai Krishna Reddy

[1]Associate Professor & HOD, Dept. of Civil Engineering, Audisankara College of Engineering & Technology, Gudur, Tirupati District, A.P, India
[2]Assistant Professor, Dept. of Civil Engineering, Audisankara College of Engineering & Technology, Gudur, Tirupati District, A.P, India
[3]M.Tech Scholar, Dept. of Civil Engineering, Audisankara College of Engineering & Technology, Gudur, Tirupati District, A.P, India

ABSTRACT: Permeation grouting is a potential method of improving the technical features of sandy soils. This method injects grout into the soil for uninterrupted the soil structure. This analysis attempts to compare infiltration injection with cement and lime grouts. A total of eight sinkholes were found in a suburban residence area. This concludes the overload for under karst caves which is the primary reason of the subsidence progression. Padding the karst cavities with cement grouts were selected as a remedy for the cavities problem. Continuous monitoring of elevation at several selected points in critical locations prior to grouting operations to fill cavities in karst terrain should be calculated and taken as a warning of significant movement or subsidence. It was considered to be an essential tool for detecting small movements and changes that can
form because of cavities and soil surfaces. The collapse was conducted by topographical site surveys, along with residential, public, common surveys as well as series of images showing key features. Station points are installed at various locations on site, and their heights were verified regularly. Periodic assessments of elevation, groundwater level and crack gauge are used as tools to assess the effect of grouting operations. The condition of available designs is verified using crack gauges and the groundwater level was checked using available piezometers. This analysis describes the state of collapse and the topographical survey that was carried out. The analysis also presents the results of an injection monitoring program and its effect on land subsidence.

KEYWORDS: Subsidence; Grouting; Survey; Soil; Topographical

Doi: 10.31838/ecb/2023.12.6.301

I. INTRODUCTION

Precast constructions have come a long way. The use of high-strength cement mortar for new construction and repairing work on construction sites is achieving its approval in civil designs.

Precast structures use high-strength fasteners and joining material that connect different components structures to ensure integrity and evaluations under structural loads. Pointing is a potential process of repairing or attaching various components of precast structures. Grout fills gaps among structural members and does not shrink, making it perfect for large equipment foundations. Cement grouts must have most fluidity and develops high compressive strength in limited period. These are effective materials for precast constructions in seismic areas. Cement grouts are also utilized to install anchor bolts and fill main cracks on roads, sidewalks as well as flyovers structures also commonly utilized in these components. Injection technology is effectively used for repairing bridges, underwater structures, and foundations. Due to its importance, different characteristics of cement mortar should be studied.

Several sinkholes occurred in the form of different dimensions in suburban residences of Kuwait [13]. Initially, it was quickly filled with gravel, sand and concrete. In the same month again two of the sinkhole, resulting in determination to remove more than 130 sinks which is at nearby homes [15]. Large research was conducted in impacted suburban residences to know the reasons of these sinkholes and to suggests the accurate

treatments. This includes geomorphological and geophysical surveys, disclosed the presence of subterranean karst cavities in the limestone bedrock beneath topsoil that caused the sinkholes. This revealed that geological profile for residences at suburban contains 35-40 meters thick sedimentary soils composed of thick to very thickness silica sand on top of karstic limestone bedrock. Sinkholes are thought to be caused by the dissolution as well as the subsequent crumbling of the sedimentary soil covers the underlying karst cavity [16].

Therefore, to reduce the outbreak of sinkholes, a treatment method of padding the subsurface voids by injecting cement grouts to a deeper depth in the pilot areas and removing the possibility of collapsing of above karst voids within limestone basement [7]. The areas of Sector A1, residences are divided as an evacuation zone, is categorized into six treatment zones TA1 to TA6, and the grouts were injected sequentially for these areas. As the grout solution contains a collapse study, drilling exploration holes with field tests, sampling by developing a grouts mixture design, standard estimation project and fills with limestone voids with cement-based grout, penetrating remains void as well as crushed anchors with cement grouts and treating overburden at final operation of grouts.

The modern society's infrastructure needs repairs and modernization, or minimum funding to reduce the frequency of those services. For example, the more sewage methods in the United States and requires regular repairs. A relatively modern and capable techniques utilized to modernize sewage systems for line existing concrete sewers with plastic lined pipes, like High Density PolyEthylene (HDPE) pipe. It is fitted into sewers and pulled or pushed into place by the sewers. To fit a concrete sewer pipe, the outer diameter of the plastic liner pipe must be smaller than the inner measurement of concrete pipes to create a gap among them. This creates an annular cavity in pipes and liners. Therefore, it is not desirable for diameters of liner pipes to be too smaller than the sewage pipes so as not to affect the capacity of the modernized sewage system. Therefore, plastic liner pipes are usually installed with a sufficient load. The difficult installations, the radial clearances (the radial extent of the gap) can vary from approximately less than 3 to 1 inch.

This analysis describes the detecting program used to implement the treatment systems for underground caverns and crushed rocks. Continuous monitoring programs focused on the impact of treatment for structures in sites, surface movements and water table changes.

II. LITERATURE SURVEY

Kavvadas, MJ, et.al [14] presents the kinds of ground deformation dimensions are commonly used in tunnel construction to ensure safety and construction quality control. In addition, types of monitoring systems, equipment used to set up early warning systems for early ground failures as well as surface structural damages are presented.

M.Shamsuddoha, Islam,., Aravinthan. M.M, Manalo.T, Lau.A, *et al.* [4] studied various mechanical and thermal parameters of epoxy mortars. The elasticity is tension and flexural modulus is 3.0-17.0 and 4.0-13.0 GPa respectively. It reports the implementation of compression strength of grout after twenty eight days with the addition of coarse filler.

F.Colangelo, G.Roviello, R.Laura, F.Claudio, and C.Raffaele, *et al*. [5] It is classified by metakaolin-based geopolymers mortar that uses organic epoxy resin. Improves the power and durability in quenched state. The microstructures show a transition zone at

the interface, similar to that of cement mortar and concrete. Correlations between microstructural parameters and mechanical characteristics have been developed.

Ismeik, M., et.al [9] explained characteristics of concrete with minerals and local Jordanian substances were studied. Compressive strength and flexibility enhance by increasing minerals additive content. The optimal rate for minerals additives depends on the W/cm ratios of mixture. Square Footage contributes best to short as well as long-terms characteristics. The Function Analysis positively influences its nature. In addition of Square Footage and Function Analysis leads to enhancement of strength in extended period.

J.M.,Ortega. J.l,Pastor. A.Albaladejo, I. Sanchez, M.A.Climent, *et al*. [1] Reports on the resilience and compression strength of cement mortars containing blast furnace slag at various water/cement ratios were classified as well as by the references of Portland grouts. The outputs of fault grouts improve resilience as well as meets compressive strength requirements as per regulations.

I.Satyarno, P.S.Aditya, C.Mayarto, D.Hadiyatmoko, P.Muhammad, and R.Afnan, et al, [2] reported that no practical method exists for designing grouts mixtures. Practical methods of designing cement-based grout mixtures depend on many graphs or empirical formulas.

Mohammed, H.M, et.al [3] analyzed compositions and characteristics of cement-depended materials grouts as well as concrete. Portland cement-based grout is liquid, allowing for deeper penetration into cracks. Cement-based materials are fitted for sealing large cracked rocks where rapid reinforcement is unrequired. For small cracks and wide crack a grout containing Portland cement and talc may be best.

H.Kamal, M.Hawary-E1, A.Abdul- Jaleel, S.Abdul-Salam., and M.Taha, *et al.* [8] described different kinds of cement-mortar mixtures that were studied for floor treatment, quality control, frequency and type of testing. The workability of the grout's material is maintained, and sufficient workability is continued to relocate, install, as well as fills the target voids.

B.B.Simsir, I.Griffin, P.B.Benedicte, and L.Rainer, et al. [10] investigated materials, techniques and evaluation techniques of grout made from lime and hydraulic lime that were reported. Various elements have been considered for use as an injection mortar. Although, there are many commercial and custom mixed grouts exist and having an standard or established techniques for evaluating grout preparation, characterization and calculation. A systematic analysis of implementation, testing, preparation and preventing conditions when using grouts is therefore essential.

A .Shah,Q.Ali, B.Alam, K.Shahzada, and A.Khan, *et al.* [6] investigated an inexpensive and easy-to-use repair method by injecting synthetic epoxy resin and cement mortar into concrete cracks. Three beams with 3-4 mm wide and load of 4-5 moderate point cracks extending to 3/4 of the depth of the beam. After sealing the crack and filling it with epoxy by injecting pressure with two variety of chemicals and cement grouts of the damaged beam was loaded until it cracked and to its maximum capacity.

Aggelis, D.G., Shiotani, T *et al*. [12] reported a repair method in which epoxy was injected to seal the sides of the crack, prevent the intrusion of aggressive substances, and restore toughness. The Rayleigh and longitudinal waves was used.

It shows the packing of materials in flat layers near the surface, while longitudinal wave tomography in thickness provides data about regions within structures. The dispersive properties of wave propagation have been exploited at various frequencies by designed tomography method, with high frequencies are shown to approximate characterization.

Ahmad, A.H and Robert, G.D. *et al*. [17] investigated the failure mechanism of concrete stone as well as its unsuccessful standards. The standards consider the interactions of brick, mortars and grouts under multiaxial stress conditions. This criterion is based on strengths that can be readily determines the standard strength testing for separate elements. In addition, the developed formulations should consider strength or geometric properties like block net-to-gross area ratio, mortar core taper, joint thickness and unjoined masonry. It predicts ultimate capacity compared with observational outputs for unbonded and bonded prisms with various mortars and grouts.

Silva, R.A., Luc, S., and Daniel, V.O. *et al.* [11] investigated the grouting will repair/reinforcement solutions for earth structures. Structural damage occurs as cracks and cavities made by drying shrinkage, heat transfer, foundation subsidence, vegetation growth, and earthquakes. When building earthen structures in seismic zones, repairing of cracks will improve performance. Design methods also need to be refined, which requires high observation studies, multiple methods to enhance mud mortar properties, and evaluation of their impact on secondary properties.

III. METHODOLOGY

The cause of monitor program used to observe the capability impact of drilling of grouts operations on available designs for surface conditions due to the treatment methods are performed. This program concentrated on sinkholes and their nature, after the implementation of treatment measures to determine the efficacy of its campaigns. The following subsection describes the techniques utilized to monitor therapeutic efficacy in the area of interest.

A building case is a completed document of land and buildings at a particular period. The investigation began by explaining the situation of available designs, identifying problems, and creating an overview of existing defects before implementing treatment methods. Numerous photographs were considered, along with overviews of place, descriptions, and close-ups for few designs and installations. For each photo, detailed localization, the date the photo was taken, photo number, and locations on the main map are noted.

Figure.1: Dilapidation Photo

A field survey of the study area was conducted at observing program at initial stage. The result of this section was a sketch for the location of all available building and utilities, including designs of fence, wall, road, sidewalk, overpasses and

underpasses, gardens, courtyards, canals, culverts and fountains, and services. Associated designs such as water pipes, sewers and utility poles (both above and below ground). These are considered "finished" drawings. Topographic surveys were primarily focused on regularly recording elevation in and around the treatment area. In addition to the points selected for each dwelling unit, elevation points are arranged on the down plane in a grid pattern at intervals of 50 m. The measured values were calculated and noted by utilizing stations of survey device. All warnings of unwanted ground movement were monitored and subjected onto maps and tables.

Figure.2: Recording Readings

The cracks gauge with an accuracy of 0.001 mm was utilized to note the movement of the choose element. It is installed on-site primarily in designs, near sinkholes, and others places where movement was doubted. Numerous crack gauges were installed in the pillars, ceilings and structural attachments for above or below plane surfaces. The gauge is installed in asphalt near progressive sinkhole. Each of them is detected by a label that contains the required data regarding the position and construction in which it will be installed.

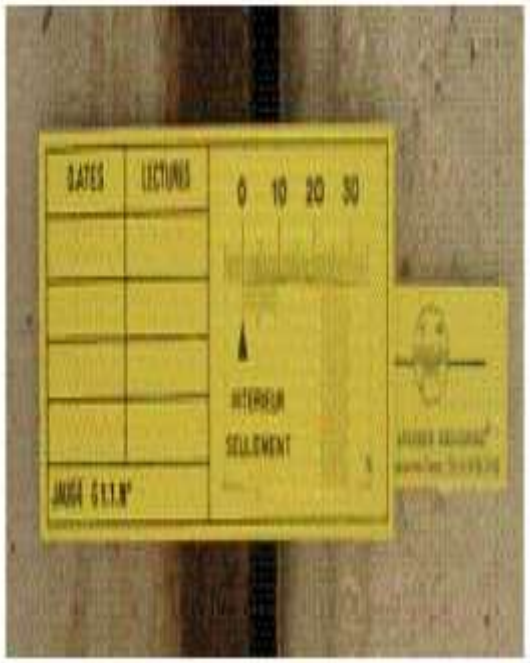

Figure.3: Crack-Meter

Precast structures use high-strength cement mortar as a connecting substance to connect different structure members, ensuring their integrity and implementation by bearing structure loads. The usage of cement mortar in precast constructions requires precision and care in joining structure members with sufficient strength. Preventing corrosion of rebars which is near to openings and filling concomitant cracks in concrete with cement grout is critical for developing the performance and life of stressed structures. Some structure materials damaged for different stress can be serviced using grouts techniques.

As a repair material, it must be sufficiently fluid to easily fill gaps and cavities in structural members. The flow properties of fresh cement mortar were tested with various water-to-binder ratios. As the substance consists of low aggregate

elements, a flow testing is acquired and implemented. Set of three cement mortar mixtures with various water/binder ratios were tested to determine the best mixture for free flow. The flux percentages achieved at various water/binder ratios. Mixtures with water-to-binder ratios as low as 0.130 result in very stiff mixtures that are difficult to compact. A cement mortar mixture with a water binder ratio of 0.140 is too fluid, resulting in segregation and water seepage.

The water absorption testing of cement mortar was performed on a cylindrical sample with a diameter of 100mm and a height of 200mm. The testing process and evaluations for the water absorption tests of grouts samples are performed according to American Society for Testing and Materials (ASTM). These tests were performed on 100 mm x 200 mm cylindrical cement mortar samples. After being poured and demolded, the cement mortar cylinders were completely submerged in water for 28 days and allowed to harden at room temperature. Remove them from the water and place them on a 10 mm or larger wire mesh to dry for 1 minute. Remove the water with dry cloth and weigh immediately. The testing was performed on four cylindrical cement mortar samples.

IV. RESULT ANALYSIS

The analysis examined the impacts of excavation and grouting on the ground and available designs. Drilling is carried out by using water or air-only drilling fluids that contains polymers. The liquid is lighter and doesn't have too many particles, so it can penetrate underground waterways more easily. It adopted two types of injection processing: mortar filling and infiltration injection.

The performance analysis for implementation and treatment of cement grout mixture for underground cavities is observed.

Table.1: Performance Analysis

Parameters	Epoxy Resin	Cement Grout
Flexural strength (%)	91	98
Tensile Strength (%)	89	92
Cracks (%)	92	85

Fig.4 shows Flexural strength comparision graph between Epoxy Resin and Cement Grout. The Cement Grout shows high Flexural strength.

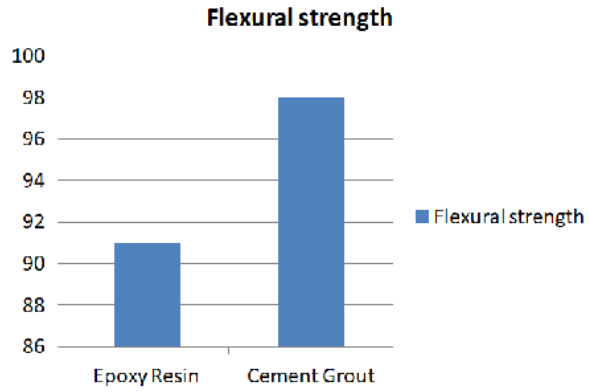

Fig.4 Flexural Strength Comparision Graph

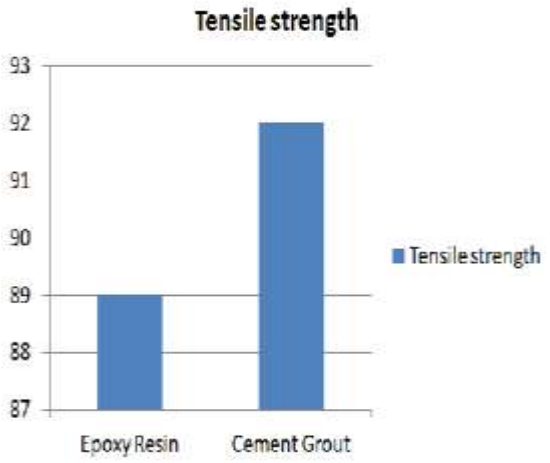

Fig.5 Tensile Strength Comparision Graph

Fig.5 shows comparision graph of Tensile Strength for Epoxy Resin and Cement Grout. Where as Cement Grout Shows higher tensile strength.

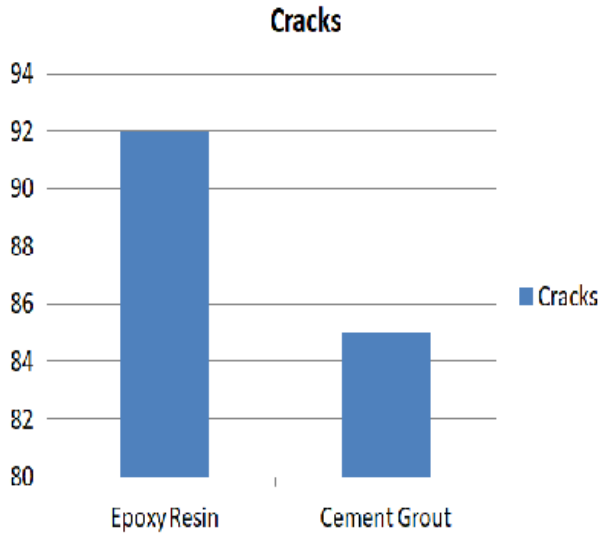

Fig.6 Cracks Comparision Graph

In this comparision graph, the cracks percentage in Cement Grout is decreased when compared with Epoxy Resin in fig.6.

V. CONCLUSION

The result of pilot areas studied depends primarily on geological profiles experiences, the nature of the work as well as sand consistency. The topsoil is 30 meters thick and enough to redistribute the porosity at the time of grouts. Rock injection was performed at fairly low pressure. Monitoring and survey activities formed an integral and significant part of the treatment of the caverns in the study place, which istreated intensively with two types of rock treatments. Void filling and infiltration injection.

As part of a water treatment implementation program, periodic assessments of elevation, water table and crack gauges were utilized as tools to assess the impact of drilling and grouting operations. No worrisome signs or important movement or subsidence was noticed during the grouting operation with low and high pressure grouting. This means there was enough space for the cavities to redistribute underground without affecting the surface.

VI. REFERENCES

[1] J.M.,Ortega. J.l,Pastor. A.Albaladejo, I. Sanchez, M.A.Climent 2014. Durability and Compressive Strength of blast furnace slag-based cement grout for special geotechnical applications. Materiales de Construction, Vol. 64, No. 313, Jan- Mar..

[2] Satyarno, I., Aditya, P.S., Mayarto, C., Hadiyatmoko, D., Muhammad, P., and Afnan, R. 2014. Practical Method of mix design of Cement-based grout. Intl Conference on Sustainable Civil Engg Structures and Construction Materials.

[3] Mohammed, H.M, 2014. *Cement-Poor Concrete and Grout for use in Underground Constructions*. Doctoral Thesis, Lulea University of Tech.

[4] M.Shamsuddoha, Islam,., Aravinthan. M.M, Manalo.T, Lau.A,. 2013. Characterization of Mechanical and thermal properties of epoxy grouts for composite repair of steel pipelines. Material and Design 52, 315-327.

[5] F.Colangelo, G.Roviello, R.Laura, F.Claudio, and C.Raffaele, 2013. Preparation and Characterization of New Geopolymer-Epoxy Resin Hybrid Mortars. Materials, ISSN 1996-1944.

[6] A .Shah,Q.Ali, B.Alam, K.Shahzada, and A.Khan 2012. Study on Performance

Evaluation of Adhesive used for Cracks Injection in Concrete. International Journal of Advanced Structural and Geotechnical Engineering, Vol. 01, No. 01.

[7] Kamal H, and Abdullah W, "Sinkholes' Detection in a Residential Area in the State of Kuwait", Arabian Journal for Science and Engineering, accepted, 2011.

[8] H.Kamal, M.Hawary-E1, A.Abdul-Jaleel, S.Abdul-Salam., and M.Taha. 2011. Development of Cement grout mixes for treatment of Underground cavities in Kuwait. International Journal of Civil and Structural Engineering, Vol. 2, No. 2.

[9] Ismeik, M. 2009. Effect of Mineral Admixture on Mechanical Properties of High Strength Concrete made with locally available Materials. Jordan Jl of Civil Engg, V. 3, N.1.

[10] B.B.Simsir, I.Griffin, P.B.Benedicte, and L.Rainer 2009. Lime-based injection grouts for conservation of Architectural Surfaces. Review in Conservation, N. 10.

[11] Silva, R.A., Luc, S., and Daniel, V.O. 2009. Grouting as a Mean for Repairing Earth Constructions. Heritage & Conservation

[12] Aggelis, D.G., Shiotani, T. 2007. Repair Evaluation of Concrete Cracks using surface and through-transmission wave measurements. Cement and Concrete Composites.

[13] Abdullah W, and Kamal H, "Characterization of Desert Karst Terrain in Kuwait and the Eastern Coastline of the Arabian Peninsula", in Proc. Sinkholes and the Engineering and Environmental Impacts of Karst, San Antonio, Texas, 2005, pp. 35-45.

[14] Kavvadas, MJ, "Monitoring ground deformation in tunnelling: Current practice in transportation tunnels," Engineering Geology, Vol. 79, 2005, pp. 93-113.

[15] Abdullah W, Mollah M, Al-Mutairi N, Al-Fahad F, and Mussallam H, "Evaluation and Treatment of Underground Cavities at Al-Dhahar Area", Vol. II, Subsurface Exploration Study in the Al-Dhahar Area, 1998, Final Report, Kuwait Institute for Scientific Research.

[16] Al-Mutairi N, Eid W, Abdullah W, Misak R, Mollah M, Awny R, Al-Fahad F, "Evaluation and Treatment of Underground Cavities at Al-Dhahar Area," Vol. I, Evaluation and Treatment of Subsurface Conditions at Al-Dhahar Area, 1998, Final Report, Kuwait Institute for Scientific Research.

[17] Ahmad, A.H and Robert, G.D. 1979. Suggested Failure Criteria for Grouted Concrete Masonry under Axial Compression. ACI Journal