Proceedings of 15th IOE Graduate Conference
Peer Reviewed
Year: 2024 Month: May Volume: 15
ISSN: 2350-8914 (Online), 2350-8906 (Print)

Influence of Organic Matter on Engineering Properties and Shear Properties of Soil: A case study of Kathmandu Clay

Jenish Sharma [a], Santosh Kumar Yadav [b], Saurav Ghimire [c]

[a, b, c] *Department of Civil Engineering, Pulchowk Campus, IOE, Tribhuvan University, Nepal*
[a] 078MSGTe006.jenish@pcampus.edu.np , [b] yadavsantoshkr@ioe.edu.np, [c] saurav.gh.2012@gmail.com

Abstract

This study offers a synopsis of the effects of natural organic content in clay on engineering properties, particularly in shallow foundation. As the past studies it shows that the organic matter in the clay plays a vital role in soil engineering properties. The engineering properties of the soil is related with the organic matter in the soil. The relation between natural organic content to its engineering properties is discussed. Additionally, it highlights the varying percentages of organic matter in natural condition in clay through laboratory tests and their consequences.

Keywords

Angle of friction, Cohesion, Natural organic content

1. Introduction

Natural organic clay, a normal soil kind discovered in numerous geographical regions worldwide, has attracted vast attention inside the area of geotechnical engineering. The presence of natural organic matter in clay can substantially influence their mechanical conduct, permeability, and balance, providing demanding situations for creation projects and infrastructure improvement. Natural clay entails a multidisciplinary method, incorporating standards from soil technology, geology, chemistry, and geotechnical engineering. The organic matter in clay soils originates from the decomposition of plant and animal substances over geological time, main to the formation of a complicated matrix that differs from inorganic clays. The presence of natural fabric can modify the fundamental properties of clay, such as its index houses, hydraulic conductivity, shear electricity, and compressibility, in the long run affecting its engineering conduct. Number of research have been conducted in the organic content of clay and its influence in engineering properties of clay. The presence of organic matter in the soil shows the unpredictable behavior which make the soil complicated.

The study [1] shows a significance role of organic matter as a small percent of natural content of approximately 3–4% might also affect the geotechnical properties of soils [1]. The effects on plasticity characteristics [2, 3] consolidation parameters [?, 4] compaction and shear strength characteristics [5, 2] had been studied by using various authors to recognize the effect of geotechnical properties with organic content. The study shows index properties, compressibility, characteristics and shear strength behavior is substantially changed by the presence of organic matter. From the studies performed at the different natural be counted, [6] stated that thein influence of organic remember on soil shear properties, liquid limit, plastic limit, and density and increase in organic matter reduce the influence of energy on Proctor test characteristics. The use of stabilizer in peat soil increases the unconfined compressive strength of the soil and the original peat soil and treated soil relations established [7].

1.1 Relationship between organic matter and engineering properties of clay

The correlation between natural organic content and engineering properties of clays, which has primarily focused on a small range (0% ≤ OC ≤ 20%). Lately [8] gathered soil samples for a examine from numerous areas positioned in Poland: Krakowiec clays from the northern a part of the Carpathian Fore deep and the natural soils from a Vistula deltaic plain. The selection of the materials turned into dictated by way of the purpose of capturing numerous consolidation conduct of soils that cover a fairly huge variety of Atterberg limits and creep susceptibility. Within the look at offered herein, each intact (I) samples and reconstituted (R) samples had been examined. The reconstituted samples of Krakowiec clays had been prepared from slurry at water content same to the liquid limit (LL).The properties of the selected soils used in the study are summarized where organic matter content increases the LL% ,PL% and Plasticity index of the soil also increases. In addition, “Creep characteristics and pore water stress changes in the course of loading of water storage tank on smooth organic soil” [8] studied by amassing pattern from water tank which was infunction after 300 days, the settlement has been measured through 3 years after creation. Cone penetration check, drilling boreholes, and discipline assessments were conducted. The soil samples were subjected to ordinary laboratory assessments to decide their homes. The end result indicates that as the proportion of organic count decreases LL % also decreases. The plasticity index increases with increases in organic content of the soil.

A research [9] on natural peat soil samples are amassed from the engineering website online close to Dianchi Lake in Kunming metropolis, Yunnan Province, China. Pattern became prepared by way of doing away with residual fibers inside the amorphous peat soil earlier than proceeding with

Property	Soil A	Soil B	Soil C	Soil D	Specification
Liquid limit (LL), %	48	46	23	40	ASTM D 4318-10
Plastic limit (PL), %	22	24	16	18	
Plasticity index (PI), %	26	22	7	22	
Specific gravity (GS)	2.69	2.67	2.64	2.73	ASTM D 854-14
Sand content %	0	2	3	10	ASTM D422-07
% Passing sieve No. 200	100	98	97	90	
Silt content %	25	19	62	41	
Clay content %< 0.005 mm,	75	79	38	49	
Natural unit weight kN/m^3	17.6	18.1	17.1	18	ASTM D 7263-09
Natural water content, %	20	32	45	24	ASTM D 2216-10
Undrained shear strength,Cu	22–25	20-22	1	120	ASTM D 2166-13
Cohesion soil, c	20.1	13.8	2	38.6	ASTM D 4767-11
Friction angle, (deg)	4	2	1	8	
Organic matter %	12–15	8–10	6–12	2	ASTM D2974-14
Compression coefficient, Cc	0.34	0.464	0.67^a	0.22	ASTM D 2435-11
Swelling coefficient, Cs	0.023	0.049	0.06	0.34	
Creep coefficient, Cα	0.020	0.038	0.020	0.0087	

Figure 1: Physical Properties of different organic soil sample [9]

No.	w_u (%)	Gs	e	W (%)	w_L (%)	w_P (%)	I_P (%)
1	0.0	2.75	0.9	58.0	66	41	25
2	2.5	2.64	1.0	63.0	69	42	27
3	5.0	2.58	1.2	69.0	73	44	29
4	7.5	2.52	1.2	73.0	81	46	35
5	10.0	2.48	1.3	77.0	97	57	39
6	12.5	2.39	1.5	87.2	136	76	61
7	16.7	2.25	1.8	109.2	150	77	93
8	25.0	2.04	2.2	139.9	200	97	104
9	33.3	1.91	2.6	185.1	292	114	178
10	37.5	1.83	3.3	211.5	316	128	188
11	41.6	1.75	3.6	225.3	349	133	216
12	50.0	1.65	3.8	247.4	387	136	242

Figure 2: Physical Properties of different organic soil sample. [9]

the pattern, and distilled water turned into added to prepare a slurry sample with a water content of two.0 instances the liquid restrict. Inside the test as the natural content material will increase unique gravity decreases. The void ratio, water content, plasticity index will increase with increase within the organic content material in the clay. The check are executed for a huge range of organic content material version from 0% to 50 %. This indicates that the physical properties of the soil is low while the organic depend content is excessive. As the organic rely will increase within the soil grow to be more porous and have more void ratio.

[10] executed a study on effect of natural matter on Swell and undrained shear electricity of treated soils in which the soil sample are dealt with and the organic remember (Irish Mosh Peat) is brought to in different ratio i.e. 5, 10, 15 , 20%. All the soils are prepared and examined. The check shows that the soil wherein the organic be counted is not blended has low moisture content in and the pattern having excessive organic matter content material have low moisture content material. It suggests that extra the organic matter is gift in the soil better is the moisture content material. Inside the soil sample 1 which don't have any organic matter have 42.5 % LL and in the progression of the organic count increases from 5,10 15 and 20 it will become 41.Ninety, forty two. Seventy five. Forty six.01 and 48.03 .It suggests that the LL% will increase within the growth in the natural content material. The research paper additionally indicates that the plasticity ratio (R=LL/PI) decrease with the increase in organic count number content material. Within the above check the organic depend become added on top of things mechanism.

[11] observe on reconstituted clay (RC) and natural clay (RO2) samples which were organized the usage of regionally available clay and organic clay with natural content material (OC) 26%. The organic soil gathered from a intensity of one–2 m from spherical degree is amorphous in nature with decomposed plant remains being the principle materials. The OC of the soil become acquired by means of locating the loss on ignition following ASTM D2974 (ASTM 2007) after igniting 50 gm of oven dried soil in a muffle furnace at approximately 450uC till there's no change within the weight. The index properties of soil were determined where it shows that the LL%, PL% and PI increases with increase in organic content while specific gravity decreases.

1.2 Relationship between organic matter content and Shear characteristics of clay

[9] observes that the organic matter content increases, the cohesion increases, the friction angle decreases, and the shear strength decreases. When OC 7.5% and OC 37.5%, the cohesion, friction angle, and shear strength have obvious transitions. Under different organic matter content, the difference in the interaction between organic matter and soil particles leads to the difference in shear characteristics of clay. When the organic matter content is less than 7.5%, the clay soil exhibits mineral properties; when the organic matter content is 7.5% - 37.5%, the clay soil exhibits the properties of mineral- free organic matter; when the organic matter content exceeds 37.5%, the clay soil exhibits nature of free organic matter.

No.	w_u (%)	Shear strength (kPa)				c (kPa)	φ (°)
		$\sigma_v = 50$ kPa	$\sigma_v = 100$ kPa	$\sigma_v = 150$ kPa	$\sigma_v = 200$ kPa		
1	0	40.0	72.9	105.7	138.6	7.2	33.3
2	2.5	39.0	70.4	101.8	133.1	7.7	32.1
3	5.0	37.4	66.0	94.7	123.3	8.8	29.8
4	7.5	36.9	64.4	91.9	119.4	9.4	28.8
5	10.0	36.3	63.3	90.2	117.1	9.4	28.3
6	12.5	35.8	61.7	87.7	113.6	9.9	27.4
7	16.7	35.9	60.4	84.9	109.4	11.4	26.1
8	25.0	32.3	52.9	73.5	94.1	11.7	24.4
9	33.3	31.2	48.9	66.6	84.3	13.5	21.5
10	37.5	30.7	46.5	62.4	78.2	14.8	17.6
11	41.6	30.8	46.5	62.2	77.8	15.1	17.4
12	50.0	30.5	45.5	60.4	75.3	15.6	16.6

Figure 3: Relationship between organic matter content and Shear Strength [9]

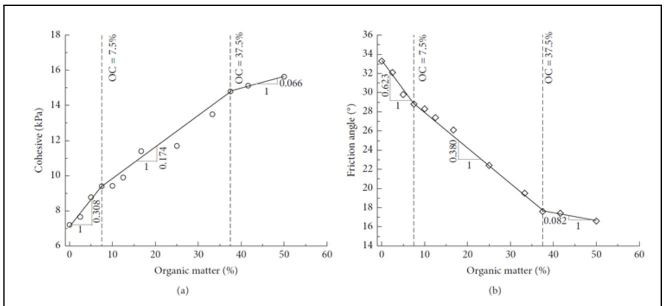

FIGURE 10: Relationship between organic matter content and cohesion and friction angle. (a) Cohesion. (b) Friction angle.

Figure 4: Relationship between organic matter content and cohesion and friction angle [9]

[12] finds that effective angle of friction (ø) for normally consolidated peats, as determined from consolidated undrained triaxial compression tests, does not appear to depend on organic content or type of peat. It varies between 40° to 60° with an average value of 53°. It is lower for organic soils (~41°). Effective cohesion is, in general small for peats.

[13] used hydrogen peroxide to take away natural substances from the unique soil and then introduced humic acid to prepare organic soil with natural matter content material of 0%-4%, and the engineering properties of soil with different natural remember contents have been studied. The outcomes showed that the plasticity, undrained shear power, and compressibility of soil elevated with natural be counted content. Booth and Dahl [1986] eliminated the natural be counted from sedimentary soil by using hydrogen peroxide solution after which mixed them with authentic sedimentary soil in proportion to prepare samples of various Natural be counted content (0.57 %-3.2%). ,e results display that organic depend has a substantial correlation with liquid restriction, plasticity index, and unique gravity. However, this technique changed into complex, time-ingesting, and onerous and turned into only suitable for soil samples with minimal natural content material.

The sample collected from different places have different type of organic matter the type of organic matter is not considered in the study.

2. Methodology

2.1 Sample Collection

The methodology employed in this study involves a structured and comprehensive approach to investigate the influence of organic matter on the geotechnical properties of natural soils within Kathmandu Valley. The first step entails the collection of undisturbed soil samples from diverse locations, representing various soil types across the valley. The three samples are collected by the visual judgments,color and odor of the soil. The sample is collected from Thapathali near Norvic Hospital, Kirtipur , and Tukucha The Shelby tube/Shelby sampler, is used for the collection of undisturbed soil samples from below the ground surface.Comprising a cylindrical steel tube with a cutting edge and a cutting shoe at its base, the Shelby tube is meticulously employed to maintain the integrity of soil samples during extraction. The process involves lowering the tube into a borehole or drill hole, where it precisely slices through the surrounding soil to capture a cylindrical section within. Careful extraction follows, preserving the undisturbed nature of the sample. To prevent any contamination or disturbance, the open end of the tube is securely sealed for transport. Once in the laboratory, the undisturbed soil sample undergoes rigorous analysis, enabling geotechnical engineers and soil scientists to assess crucial properties such as moisture content, grain size distribution, shear strength, and compressibility. This invaluable tool ensures the accuracy of geotechnical assessments, engineering designs, and environmental evaluations, particularly when dealing with sensitive or cohesive soils where traditional drilling methods might compromise sample integrity. The water content of the soil sample is determined keeping the sample in the oven. The dry sample is burn in the muffle furnace to determine the quantity organic content. The density, liquid limit, plastic limit and specific gravity is determined. The direct shear test/Triaxial test is conducted to determine cohesion and angle of internal friction. Ultimately, the research seeks to provide valuable insights into the intricate relationship between organic matter and soil properties, offering practical recommendations for sustainable geotechnical engineering practices and land use planning within Kathmandu Valley.

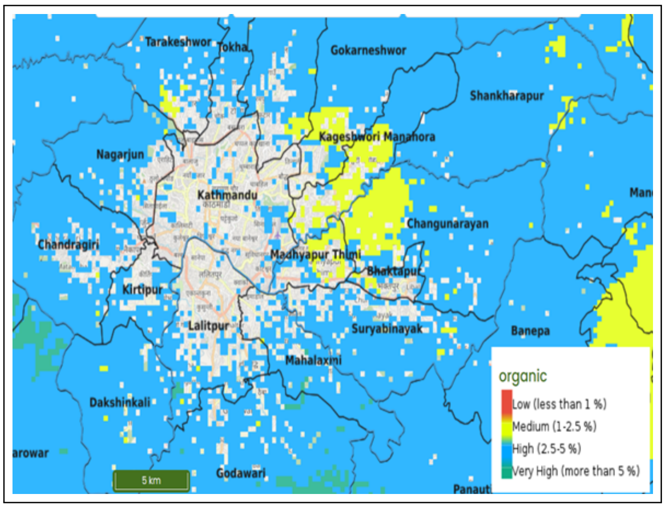

Figure 5: Organic Content in Soil of Kathmandu Valley.

2.2 Lab Tests

2.2.1 Water Content Determination

The water content determination test, as per ASTM D 2216, is a vital laboratory procedure done in geotechnical engineering to ascertain the moisture content of a soil sample accurately. This test is fundamental because water content plays a significant role in determining a soil's engineering properties, including its compaction characteristics, shear strength, and permeability. The ASTM D 2216 standard outlines a well-defined procedure for conducting the water content determination test.

2.2.2 Organic Matter Content Determination

ASTM D2974 is a standard test method used for the determination of moisture content, ash content, and organic matter content in peat samples. This method is particularly valuable in the field of geotechnical engineering, as it provides critical information about the organic matter content of the peat or soil.

2.2.3 Specific Gravity Determination

The test is performed to determine the specific gravity of soil by using a pycnometer. Specific gravity is the ratio of unit weight of soil at a stated temperature to the unit weight of same volume of gas-free distilled water at a stated temperature.

2.2.4 Atterberg Test

ASTM D4318 is a standard test method used to determine the Atterberg Limits of fine-grained soils, which include the

Table 1: Observed Data

Bore Hole No	OC %	Water Content	Density	Specific Gravity
Thapathli	3.26	36.67	17.64	2.49
Tukucha	5.35	75.55	15.465	2.52
Kirtipur	6.93	83.6	14.522	2.51

Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI). These parameters provide valuable insights into the soil's behavior, including its moisture sensitivity, consistency, and suitability for construction and engineering applications. The Atterberg Limits test is a fundamental procedure in geotechnical engineering and soil science.

2.2.5 Direct Shear Test

ASTM D3080 is a widely recognized standard test method used in geotechnical engineering to determine the shear strength properties of soil materials. This test is known as the Direct Shear Test and is essential for assessing the response of soils to shearing forces, which is critical for various engineering applications, including foundation design, slope stability analysis, and earthworks construction.

2.2.6 Triaxial Test

ASTM D 2664-95a is a standard test method used in geotechnical engineering to perform triaxial test. (CU).

3. Result and Discussion

From the lab tests conducted on the samples collected from different sources, relationship between organic content and basic properties of soil are determined.

3.1 Influence of Organic Content over Atterberg Limit

As the organic matter increases the liquid limit and plastic limit increase but the relation of organic matter with the plasticity index (PI) is not significant.

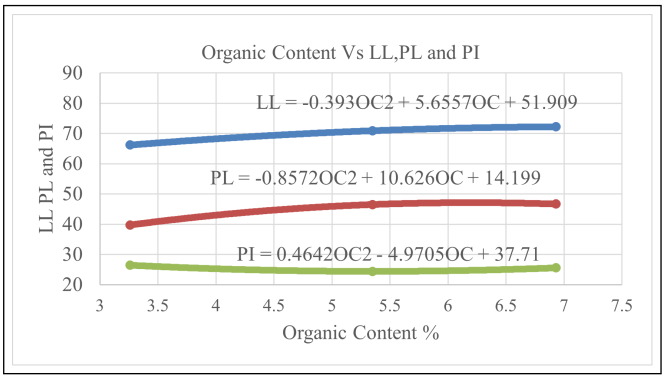

Figure 6: Observed relationship between organic content and Atterberg Limits

3.2 Influence of Organic Content over Strength Parameters

From the observation, it can be seen that as the organic content increases, angle of friction decreases while in case of cohesion, the increment in organic content leads to increase in the cohesion.

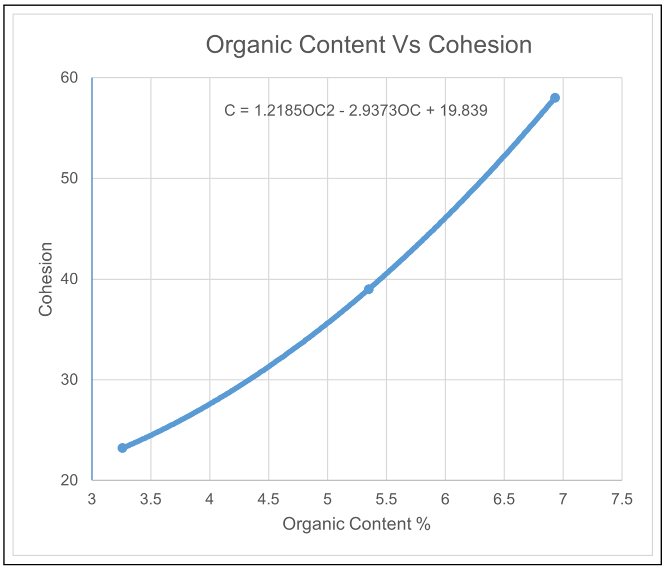

Figure 7: Observed relationship between organic content and cohesion

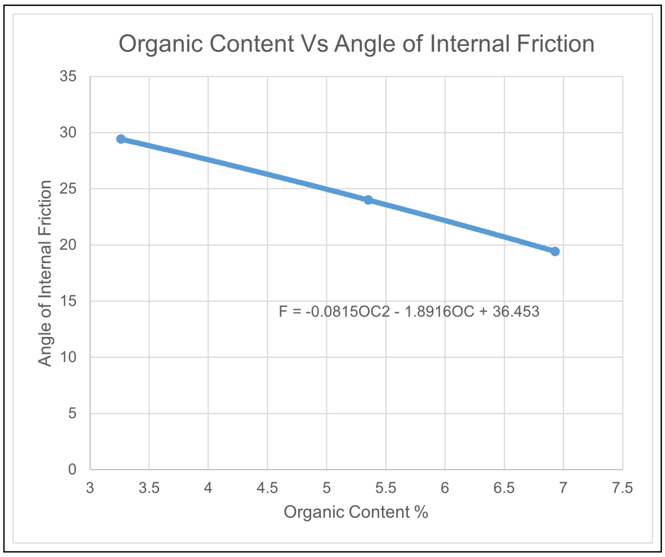

Figure 8: Observed relationship between organic content and angle of friction

4. Conclusions

The presence of organic matter in clay soils has a significant impact on their engineering properties. The studies leads to the summary that highlight the complex relationship between organic matter content and various parameters, such as liquid limit, plasticity index, specific gravity, cohesion, friction angle. Overall, the research suggests that as the organic matter content increases, the liquid limit, plastic limit increases whereas plasticity index relation is not significant , indicating higher moisture retention and greater potential for volume change. However, the specific gravity of the soil tends to decrease with higher organic matter content, indicating a decrease in density. Furthermore, the cohesion increase with increase in organic content where as angle of internal friction decrease as the organic matter content increases. This suggests that the presence of organic matter reduces the soil's ability to resist shear stresses, making it more susceptible to deformation and instability. It is important for geotechnical engineers to consider the influence of organic matter when analyzing and designing structures on clay soils. The unpredictable behavior of soils with organic content poses challenges for construction projects, requiring careful evaluation and appropriate mitigation measures to ensure the safety and stability of the infrastructure. However, it is worth noting that the behavior of soils with organic matter is influenced by various factors, including the type of organic matter, soil structure, clay content, aggregation effects, and environmental conditions. Therefore, a comprehensive understanding of site-specific conditions and thorough laboratory testing is necessary to accurately assess the engineering properties and behavior of treated soils. The studies reviewed emphasize the importance of considering organic matter in geotechnical engineering practices and highlight the need for further research to deepen our understanding of the complex relationship between organic matter and soil behavior.

References

[1] Roland Pusch. Role of organic content for the geotechnical behaviour of clays. *International Journal of Environmental Impacts: Management, Mitigation and Recovery*, 1:92–104, 1 2018.

[2] James S. Booth and Alfred G. Dahl. A note on the relationships between organic matter and some geotechnical properties of a marine sediment. *Marine Geotechnology*, 6:281–297, 1 1986.

[3] Satoshi Matsumura, Seiichi Miura, Shoji Yokohama, and Shima Kawamura. Cyclic deformation-strength evaluation of compacted volcanic soil subjected to freeze-thaw sequence. *Soils and Foundations*, 55:86–98, 2 2015.

[4] Eko Budianto, Dina Limbong Pamuttu, Simon Tatai, Daud Andang Passalli, and Hairulla Hairulla. Analysis of unconfined compressive strength in clay mixed with sand. volume 328. EDP Sciences, 12 2021.

[5] Rinku Varghese, S. Chandrakaran, and K. Rangaswmay. Geotechnical behaviour of different organic matter on clayey soils. *Geomechanics and Geoengineering*, 16:288–297, 2021.

[6] Fawzi Hamouche and Rachid Zentar. Effects of organic matter on mechanical properties of dredged sediments for beneficial use in road construction. *Environmental Technology (United Kingdom)*, 41:296–308, 1 2020.

[7] Prabir K. Kolay and Siti Noor Linda Taib. *Physical and Geotechnical Properties of Tropical Peat and Its Stabilization*. InTech, 9 2018.

[8] Mudhafar K. Hameedi, Raid R. Al Omari, and Mohammed Y. Fattah. Compression and creep indices of organic clayey soil. volume 671. Institute of Physics Publishing, 1 2020.

[9] Yue Gui, Qiumin Zhang, Xiaqiang Qin, and Jianfei Wang. Influence of organic matter content on engineering properties of clays. *Advances in Civil Engineering*, 2021, 2021.

[10] A. T.S. Azhar, W. Norhaliza, B. Ismail, M. E. Abdullah, and M. N. Zakaria. Comparison of shear strength properties for undisturbed and reconstituted parit nipah peat, johor. volume 160. Institute of Physics Publishing, 12 2016.

[11] Konsam Rambha Devi, Ramendu Bikas Sahu, and Sibapriya Mukherjee. Response of organic clay under cyclic loading. *International Journal of Geotechnical Engineering*, 8:130–143, 4 2014.

[12] Mukti Bahadur Khatri. Small and medium scale enterprises and their role in employment generation in nepal. *Tribhuvan University Journal*, 33:129–140, 5 2020.

[13] M A Rashid and J D Brown. Influence of marine organic compounds on the engineering properties of a remoulded sediment, 1975.