A Review on the Effect of Oil or its Derivatives on Gepsious Soil

Alaa Ahmed sekhi[1*], Hussein Abd Shaia[2]

[1] Department of Civil Engineering, University of Thi-Qar, Nasiriya 64001, Iraq.

alaasekhi@gmail.com.

[2] Department of Civil Engineering, University of Thi-Qar, Nasiriya 64001, Iraq.

h.shaia@utq.edu.iq.

*Corresponding author email:alaasekhi@gmail.com.

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Abstract

Gypseous soils categorized as the most arduous soil because of their intricate and unforeseen behavior. Gypsum soils can be present in many parts of the world and are abundant in dry areas, and they may be close to oil pollution areas, so their geotechnical characteristics are affected by the presence of oil or its derivatives. Oil residues can be used as one of low-cost products to improve some properties of gypsum soils. It is necessary for geotechnical engineers to know the engineering properties of this type of soil as this soil is classified as collapsed, solid when it is away from water and once gypsum soil meets water it becomes weak towards high compressive forces due to the dissolution of gypsum. Because of this, many researchers have worked to find the best ways to improve this type of soil. This paper summarizes most of these previous studies related to the impact of petroleum pollution on gypsum soil, in addition to studies related to the use of petroleum materials or one of its derivatives to improve the bearing capacity of gypsum soil and reduce collapse and permeability.

Keywords: Oil-pollution, Gypseous soil, Geotechnical properties.

Introduction

Soils containing gypsum are called gypseous soils (sometimes called gypsiferous soils). They can be present in many parts of the world and are abundant in dry and semidry environments [1-3]. Gypseous soils are one of the most complicated geotechnical and civil engineering materials to work with. When dry, gypseous soils are relatively hard. In contrast, when gypseous soils are exposed to moisture, the melting of gypsum among soil grains has been observed, causing a rapid collapsible potential [4]. Due to their complicated and unpredictable nature, gypseous soils are regarded as problematic soil. In addition to the gypsums' kinds and contents, the rate of dissolution is influenced by environmental variations in moisture content caused by fluctuations in the surface or subsurface water, and flow situations [5]. Gypseous soils are easily recognized as being extremely susceptible to environmental changes. Generally, much study has been conducted to explore and better understand the behavior of Gypsum soils, as well as to improve its geotechnical properties. Gypsum's content in soils might cause several issues for the constructions that that are built on top of such soils, as well as causing it to behave unpredictable manner [6-8]. The improvement of gypseous soils is significant. There are several researches conducted to improve the properties of gypsum soils, such as adding certain materials to these soils, including oil additives or some of its derivatives [9,10-16], or studying the engineering properties of these soils when they are contaminated with crude oil or its products [17,18,19-24]. Oil pollution can occur as a result of several factors, including pollution resulting from leakage of gas transmission pipelines, or leakage of crude fuel, or resulting from land or marine discharge of petroleum products, or caused by accidents during transportation of petroleum products, and wars may also be a cause for this. Conducting research on gypsum soils contaminated with these products provides important information about the properties of these polluted soils and the possibility and methods of treating or reclaiming them for construction. This work aims to present a literature survey on the studies that dealt with gypseous soils with oil or its derivatives as a result of pollution or as a material to enhance the characteristics of gypsum soils.

2. Impact of oil and its derivatives on gypseous soil characteristic:

a. Sh. Seleam, (1988)[17] investigated the impacts of two sorts of petroleum products (kerosine and gasoil) on the properties of gypseous sandy soil. Both kerosine and gasoil appeared to have the same effect on soil behaviour, causing swelling in soils with low gypsum concentration when contaminated.

b. Al-Aqaby, (2001) [18] evaluated the impacts of kerosine on the characteristics of a gypsiferous soils, noting a reduction in cohesiveness of soil containing gypsum ranging from thirty percent to sixty seven percent when submerged in kerosine or water, as well as a reduction of six degrees of coefficient of friction when submerged in kerosine.

c. Shihab et al., (2002) [9] evaluated the impact of fuel oil (FO) on gypseous soil. The application of FO decreased the solubility of gyps, as demonstrated by a decreasing the dissolution rate coefficient (K). The value of K is mostly determined by the soil's specific surface area.

d. Dunya, (2017) [19] investigated the engineering and geotechnical characteristics of gypseous soils by using heavy fuel oil (HFO). According to the findings, the average of HFO penetration depth and settlement reduces as soils' density increases, whereas both increase with increasing oil head. Results show increasing settlement of gypseous content and decreasing penetration depths, and internal friction angle (Ø) increases in gypsum soils.

e. Al-Adili et al. (2017)[20] evaluated the influence of crude-oil (C-oil) pollution on stiffness properties of gypsum soils. They presented the impact of various percentages of C-oil pollution on the geotechnical characteristics of gypseous soils. The study demonstrates that the volume wetness of soil decreased to achieve a maximum dry unit weight with increasing pollution content in the soil, as well as the liquidity. Because of the lower unit weight of the pollution agent, the specific gravity of gypseous soils reduces as pollution agent rises. The dry density reduces as pollution agent content increase. The consolidation (Cv), compression (Cc), and swelling (Cr) indicators have been all raised when the gypseous soil sample was immersed in oil, according to the consolidation test. The existence of some organic substance in C-oil might be responsible for the increase in these indicators. The voids ratio and permeability of the specimens were lowered after they were immersed in oil (Table 1). When 4, 8, or 12 % crude oil is added to gypseous soil, the settlement increases dramatically to 56.5, 64.5, and 58%, respectively (Fig. 1).

Table 1: consolidation test results for gepseous soil soaked in water and oil

Properties	Soil soaked with water	Soil soaked with oil
C_V, mm^2/min	56.78	57.72
C_r	0.0181	0.0257
C_C	0.0543	0.0634
Hydraulic conductivity K, cm/s	3.25E-8	4.05E-8
e_0	0.48	0.45
Gypsum content, %	25	25

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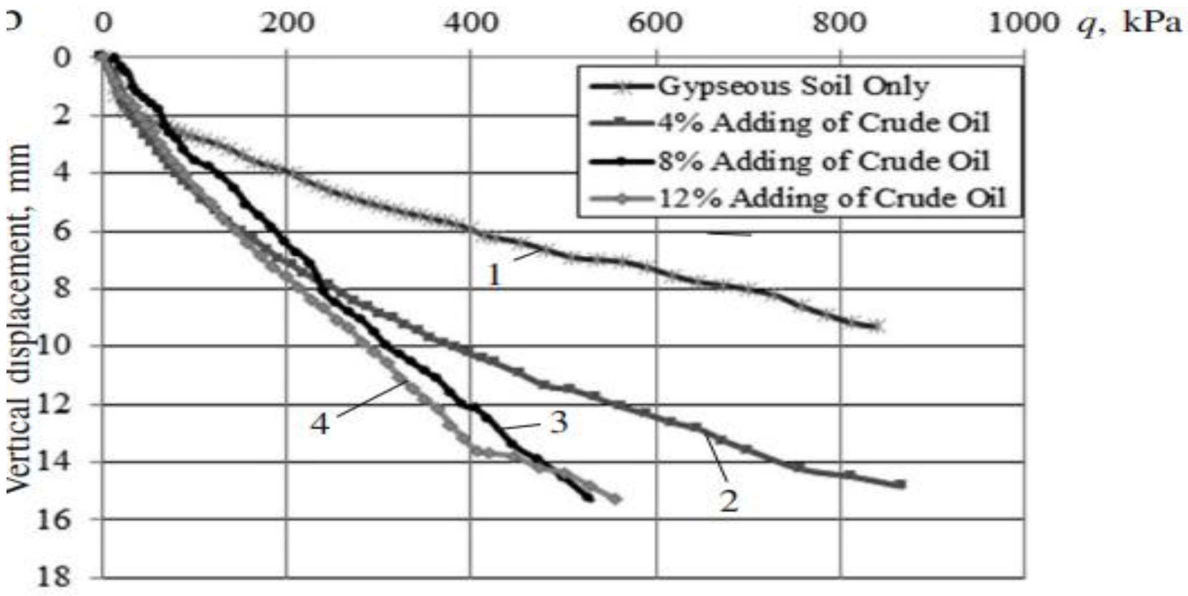

Fig. 1: The vertical displacement of the gypseous soil with various percentages of C-oil.

f. Younus and Zedan, (2021)[21] They studied the performance of a square foundation built on kerosine-contaminated gypseous soil. They tested soil that had a gypsum content of 62 percent. The results of the correlation between pressure and settlement demonstrate that when consolidated to field unit weight without submerging, gypsiferous soil has good strength. The strength for resisting the compressive stress of the polluted gypsiferous soil testing does not increase since the strength is lowered when contrasted to the non-polluted gypsiferous soil (Fig.2), but the displacement does a little improve. The soaking gypseous soils demonstrated an enhancement in bearing strength as well as foundation displacement (Fig. 3).

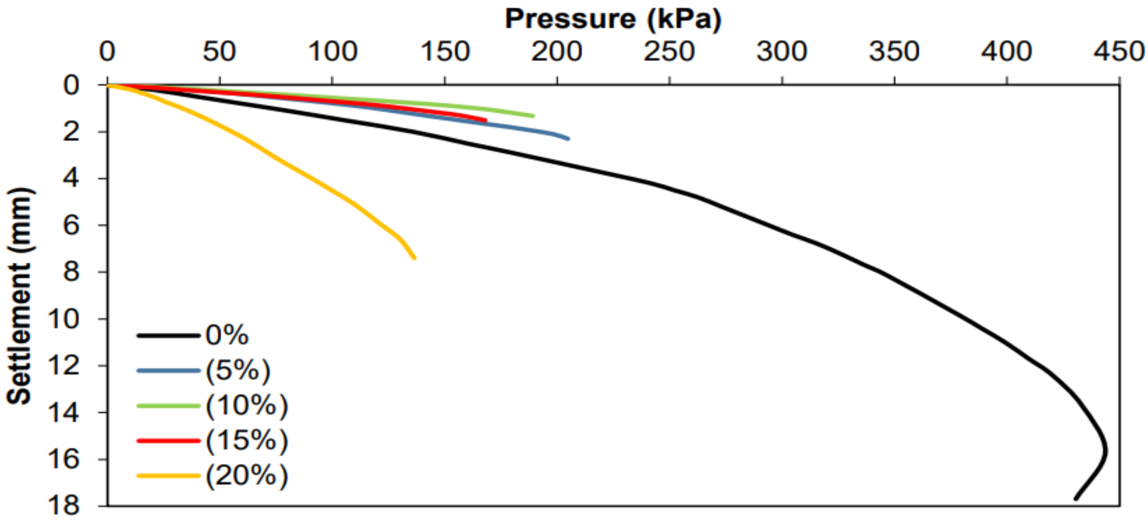

Fig. 2: Pressure-settlement curves for polluted dry gypsiferous soil with depth (B).

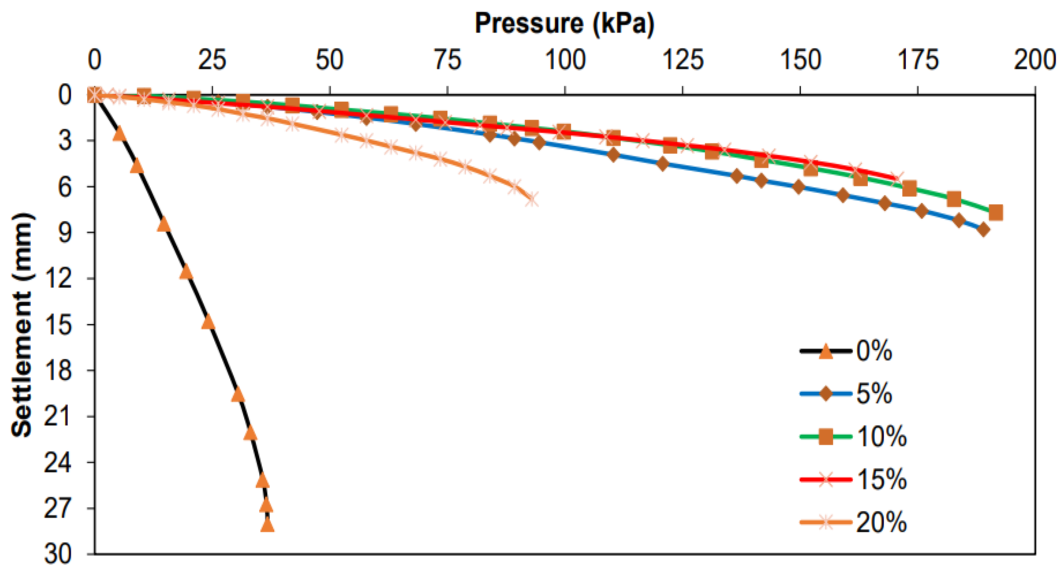

Fig. 3: Pressure-settlement relations for polluted gypsiferoussoil with depth (B) (with submerging).

g. Al-Obaidi et al., (2020) [22] established an empirical system to evaluate the durations for filtration of polluted waste products (HFO) into various gypsiferous soils specimens. The results revealed that as the temperature of the HFO waste increased, the filtration speed in the initial phases of precipitation increased rapidly fig 4, and the saturation value of soil decreased. Furthermore, increasing the HFO waste heat lowers settlement for soils with high and medium gypsum's levels while increasing settlement for soil with low percentages of gypsums.

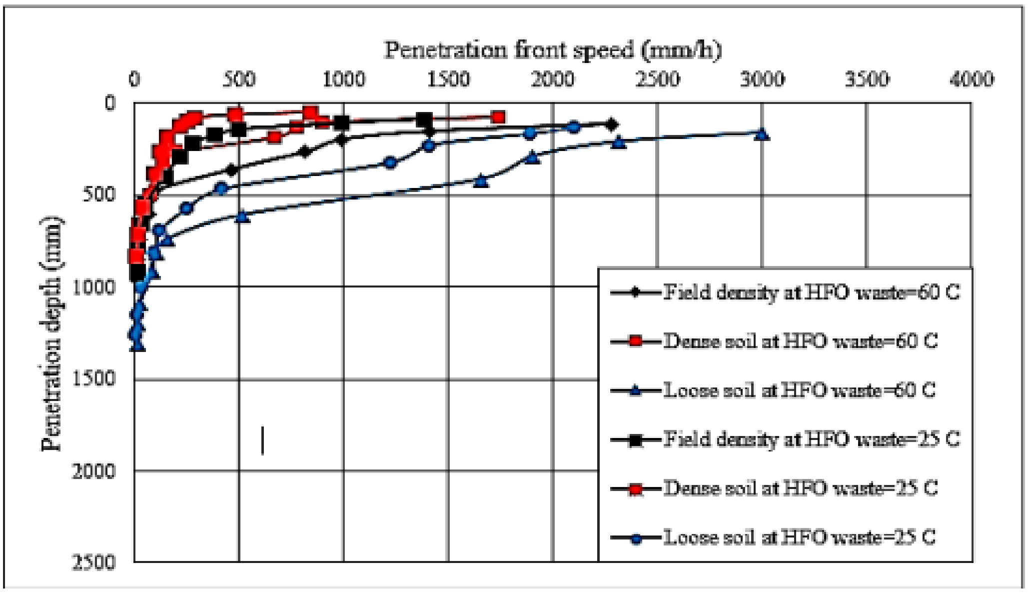

Fig. 4: Empact of heating HFO waste on filtration forwarding speed

The behavior of the characteristics of gypsum soil polluted with oil or one of its derivatives can be better understood through the summary of the literature review above in Table 1.

Table 1: Impact of oil and its derivatives on gypseous soil characteristic

Ref.	Oil types	Tested parameters	Results
[17]	Ker. & G-oil	Swelling index	1% of kerosine or gasoil caused swelling in soils with low gypsum concentration
[18]	Ker.	Direct shear	The presence of kerosine in the soil caused a reduction in both the angle of friction and the coefficient of cohesion.
[9]	F-oil	Permeability	1.5% of fuel-oil caused a reduction in the coefficient of permeability.
[19]	HFO	Settlement	Heavy fuel oil might cause an increment in soil settlement
[20]	C-oil	Compaction, specific gravity, consolidation	The optimum moisture content, maximum unit weight, and specific gravity dropped with increasing oil content, while all of consolidation, swelling, and compression indices increased.
[21]	Ker.	Bearing capacity vs. settlement	As increasing kerosine-polluted in dry soil, the bearing capacity reduced slightly with significant reduction in the settlement.
[22]	HFO	Degree of saturation, settlement	As the temperature of the heavy fuel oil increased, the saturation degree of the high and medium gypseous content soils reduced and the settlement increased for the low gypsum content soil.

*Ker.: kerosine, G-oil: gasoil, F-oil: fuel-oi, HFO: heavy fuel oil, C-oil: crude oil

There is an urgent need to prepare more scientific research related to gypsum soil contaminated with oil or one of its derivatives, in addition to preparing comparisons between researchers' results and examining whether the results and behavior are close or contradictory. It can be noted that the previous literature lacks important properties that have not been addressed, such as the Atterberg limits, the uniaxial compressive strength test, triaxial shear test, etc.

3.Reviewing on gypseous soil improvement using oil or its derivatives:

a. Al–Hassany, (2001) [10] carried out consolidation experiments on two samples of gypseous soils, with gypsum contents of 26% and 51% mixed with fuel oil, respectively. The findings revealed that the pores of the soil filled with oil, thus preventing water escape and thereby lowering the soil's permeability, and this behaviour was conforming with Shihab et al., (2002) [9].
b. Aziz, H.Y. (2001) [11] worked on utilizing fuel oil as an addition to improve the characteristics of gypsum soil. Because of the capacity of the fuel oil to minimize the influence of moisture on the soil, the study's findings revealed increases in soil properties. The soil permeability, compressibility, and soil features during collapse were also investigated, and the result indicates that the fuel oil had the potential to enhance the examined soil parameters. Fuel oil, according to Aziz, is a useful substance for modifying the basic properties of gypseous soil, such as collapsibility and permeability, which are the soil's major issues. Their results were conforming withShihab et al., (2002) [9] and Al–Hassany, (2001) [10] in terms of permeability behaviour, and with Al-Zabedy and Al-Kifae (2020) [27] in terms of soil stability.
c. Al-Harbawy, and Al-Khashab, (2004) [12] investigated the effects of liquid asphalt kinds in stabilizing gypseous soil. Liquid asphalt (LA) serves as a waterproofing agent as well as providing cohesive strength to the soil mass. permeability of gypseous soil is increased by liquid Asphalt, and this behaviour was conforming with Sarsam& Ibrahim (2008) [25] and Shakir (2017) [26], which they also reported that the LA improves the cohesion strength calculated from uniaxial compressive test and elastic characteristics, and decreases the total strain.
d. Taha, [2006] [13] and Kadhim, (2004) [14], examined the effects of liquid asphalt (MC-30) on gypsum soils, the outcomes indicated that the liquid asphalt is an enhanced material for gypsum soils. They reported that as liquid asphalt content increased, the values of Atterberg limits, specific gravity, maximum unit weight, and collapse potential reduced, while the values of

optimum moisture content, California Bearing Ratio, direct shear parameters, uniaxial compressive resistance, improved.

e. Taha et al., (2008)[15], They investigated the efficacy of liquid asphalt as petroleum additives in improving the characteristics of gypsum soils and reported that these materials enhanced the geotechnical characteristics of gypsum soil when immersed in water. Their investigation contained two section of treatments, the first was by blending method and the second was by grouting method. They reported that the first method was the best because this method coats the soil grains with a film of the additive petroleum material, while the second method (grouting) fills the soil-porosities.

f. Aziz and Ma, (2011)[16] They study whether fuel oil (F-oil) might help improve gypseous soil. Two soils were subjected to extensive laboratory testing (with 51.6 % and 26.55 % gypsum content, Soil I and II respectively). They determined that the permeability of the treated soil was reduced as a result of the impact of increasing lubrication among the soil grains, maintaining rearrangement, and minimizing voids. Furthermore, F-oil treatment of gypseous soil reduced collapsibility (Fig.5) and compressibility. This occurred because the F-oil coated the soil grains reducing the gypsum decomposition and avoiding the collapse. The results show that the gypseous soil can be treated from the collapsibility by utilizing of 3% F-oil for clayey soils and 4% F-oil for sandy soils.

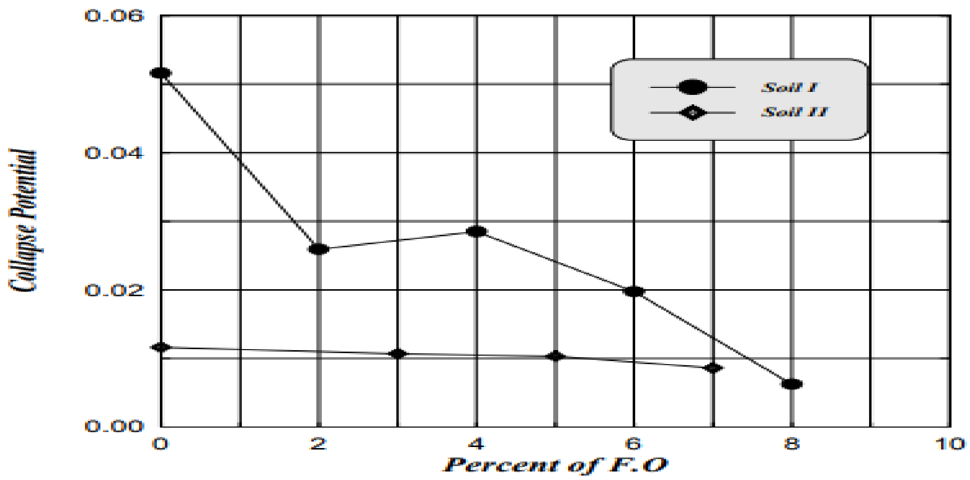

Fig. 5: The relationship between collapse potential and content of F-Oil for Soil I and II

g. Saleh Hussein, (2017) [23] evaluated the use of F-oil to improve the characteristics of gypsiferous soils, which is a low-cost substance. This substance has the potential to restrict water flow and disperse in soil voids. The gypsum percentage in the soils employed in this investigation is 49.4%. The OMC increased and MDD reduced as the F-oil percentages raised (Fig. 6). For the modified soil without submerged in water, the UCS improved as the F-oil percentages raised. The optimum improvement for (eight percent of F-oil) (Fig.7) recorded about (thirty four percent). For modified soil submerged in water, the UCS dropped to about (thirty seven percent) as contrasted to the unsubmerged but, it raised as the F-oil percentages raised. The raise and drop ratios are evaluating depending on equations (1) & (2).

$$\text{Increase Ratio} = \frac{q_u \text{ for treated soil}}{q_u \text{ for untreated soil with 0\% feul oil}} \quad \ldots\ldots\ldots\ldots\ldots(1)$$

$$\text{Decrease Ratio} = \frac{q_u \text{ soaked sample}}{q_u \text{ unsoaked sample}} \quad \ldots\ldots\ldots\ldots\ldots(2)$$

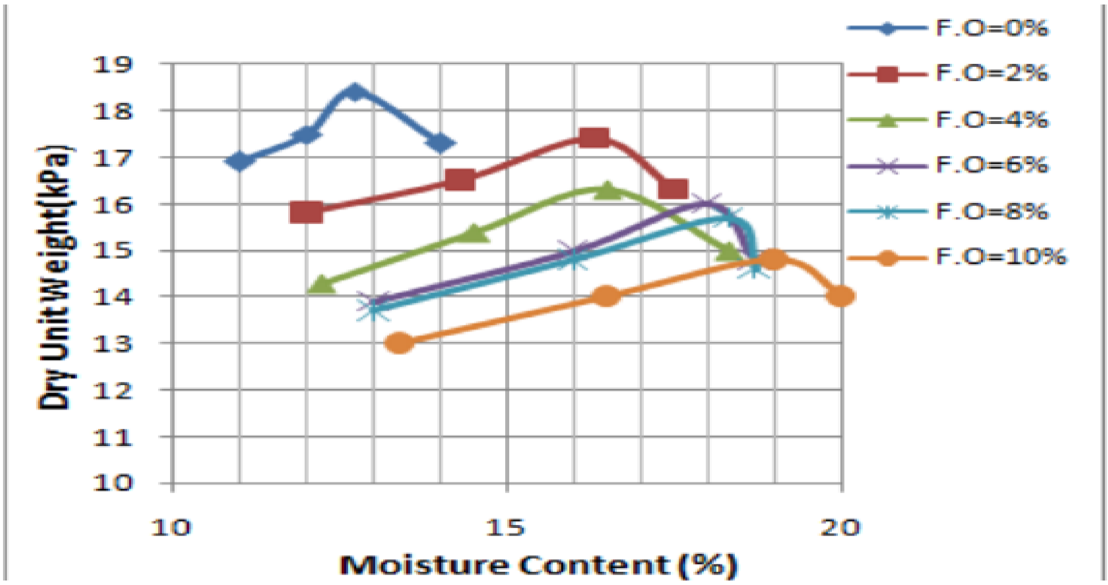

Fig. 6: compaction parameters relationship with different F-oil percentages.

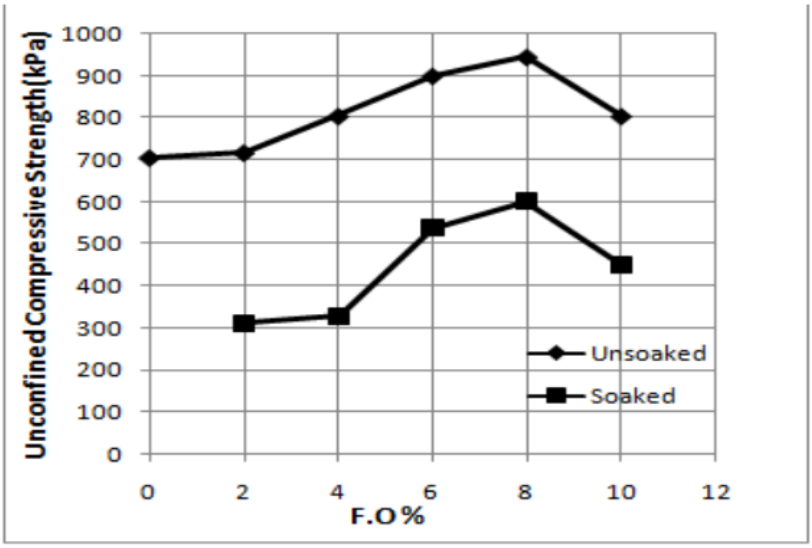

Fig. 7: Impact of F-oil levels on the maximum UCS tests.

Figures (8) and (9) represent the relationship between cohesiveness (c) and frictional coefficient (φ) with F-oil percentage for unsubmerged-submerged conditions, respectively. The Direct shear parameters (c & φ) raised as the F-oil percentages raised to an optimum percent (eight percent of F-oil) and subsequently declined in the unsubmerged state.

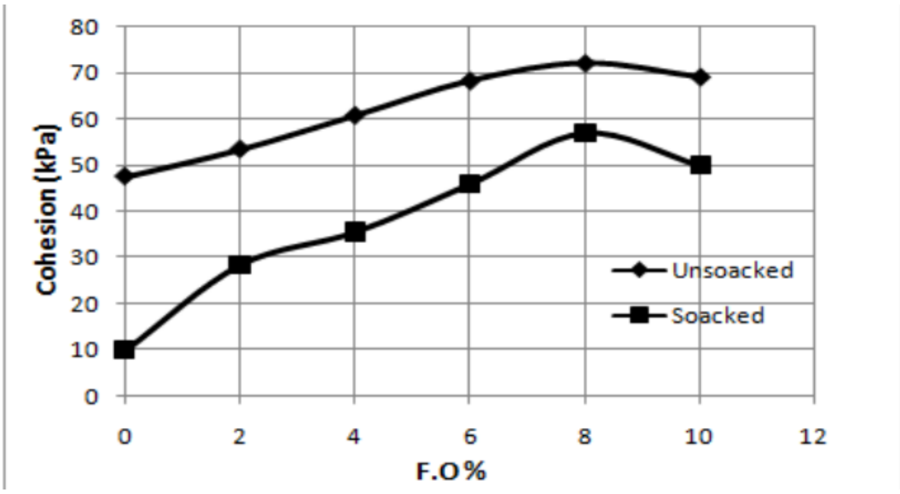

Fig. 8: Impact of F-oil levels on the cohesion of specimens (c).

This performance could be attributed to the consistency of F-oil, causes cohesive attracting and interlocking among soils' grains, which increases in direct shear parameters, then reduces because of the F-oil films encasing the grains raises, preventing link among grains and thus reducing friction. The findings revealed that utilizing F-oil with optimum percent (8%) is a better solution for gypsum soil concerns. Using this substance, engineers were able to enhance the engineering characteristics of gypsiferous soils and minimize collapsibility (fig.10), particularly when the soils were moist.

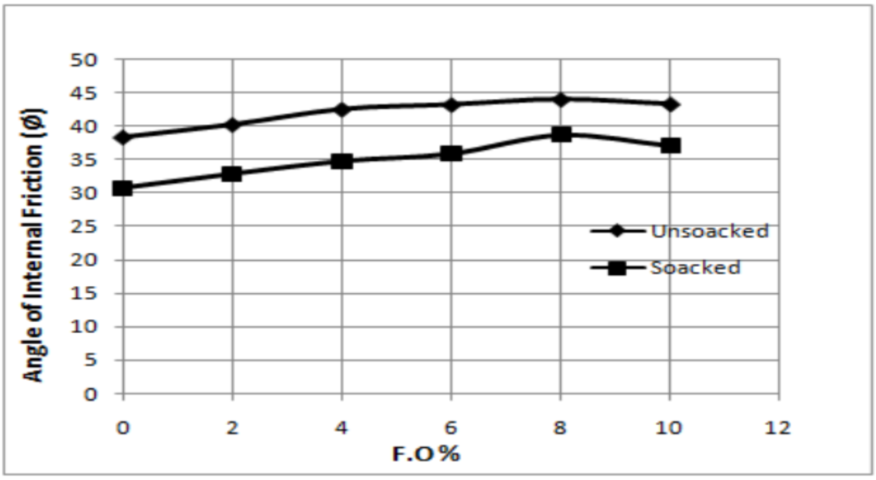

Fig. 9: Impact of F-oil levels on the internal friction angle (Ø).

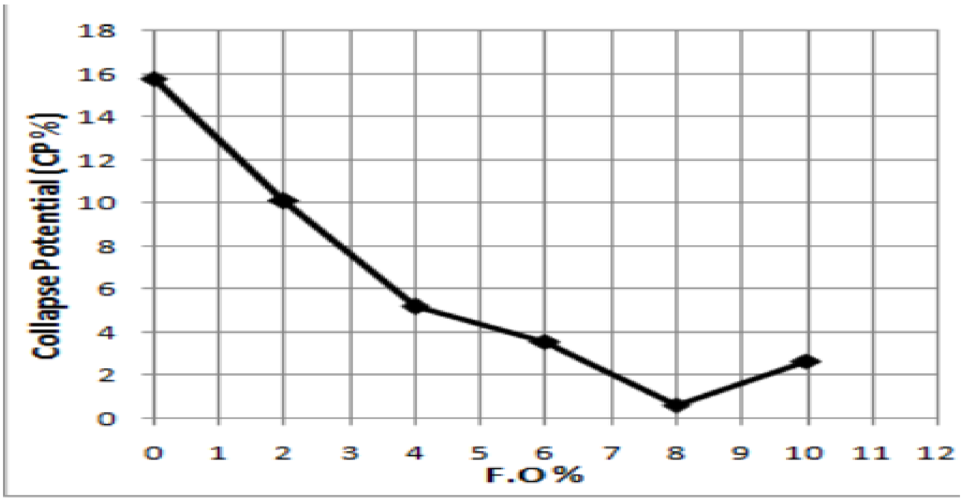

Fig. 10: The effect of F-oil levels on collapse potential.

Al-Adhamii et al., (2020)[24] examined the geotechnical characteristics of crude-oil (C-oil) polluted gypsiferous soils, as well as the potential of utilizing the C-oil as a stabilizer agent. They conducted experiments on soil that contained thirty four percent of gypsum. Their results demonstrated that the L.L of gypsiferous soil raises with raising C-oil percentages, while the soil converts from nonplastic to plastic after adding C-oil for all percentages by raising plasticity-index from three percent to twenty eight percent with raising C-oil percent from zero to nine percent, respectively (Fig.11). The optimum C-oil content for MDD (fig.12) and UCS (Fig. 13) is six percent. On the other hand, when the C-oil concentration rises, the OMC decreases. The cohesion (c) rises with C-oil, while the frictional coefficient (Ø) decreases. The utilize of nine percent of C-oil decreases the soaking effect on gypsiferous soils and enhances the collapsible potential (Fig. 14).

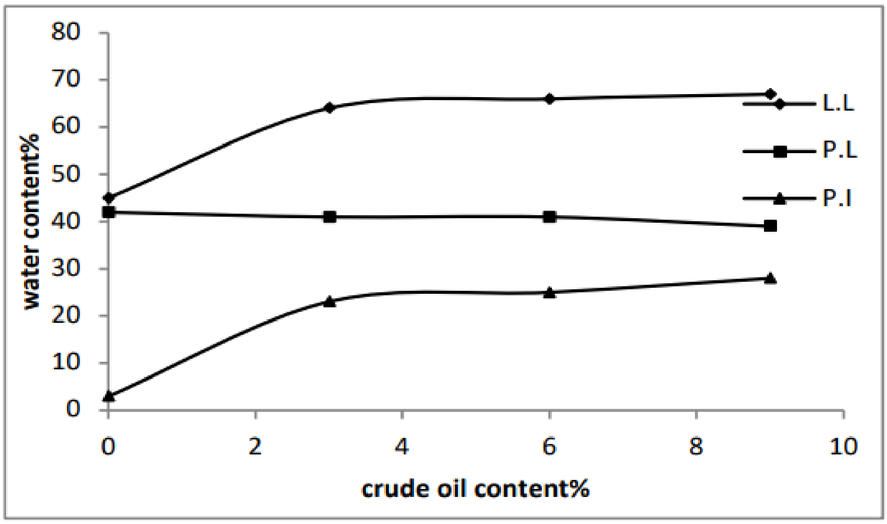

Fig. 11: Effect of C- oil percentage on Atterberg limits.

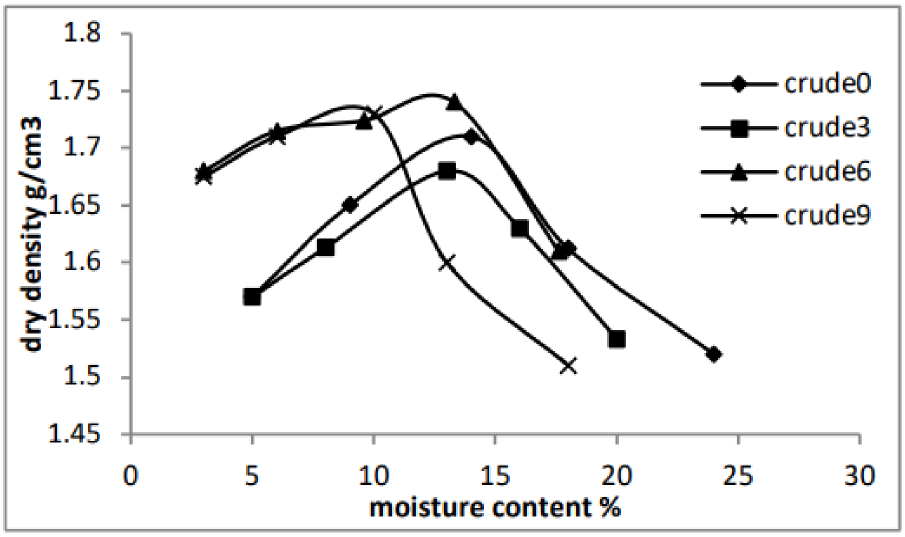

Fig. 12: Relationship between DD and MC of gypsiferous soil for various C-oil levels.

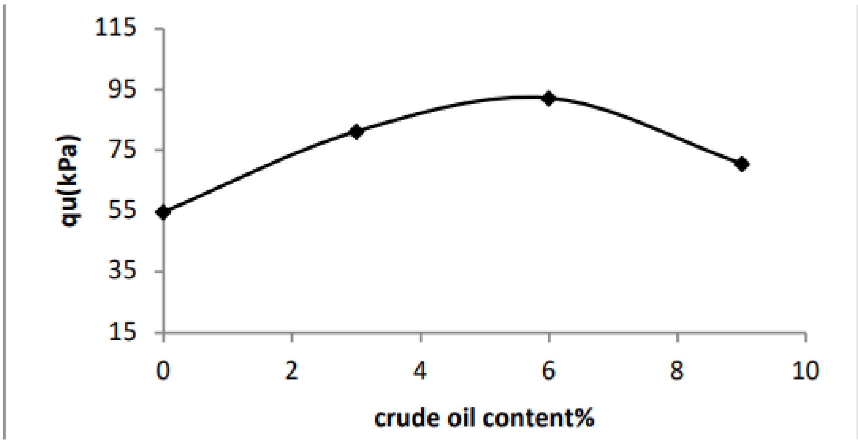

Fig. 13: Maximum values for UCS with C-oil percentage relationship.

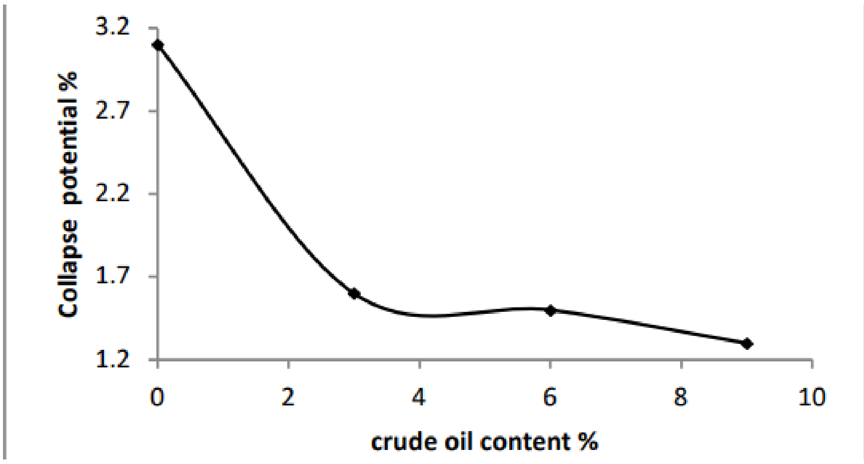

Figure 14. Relationship between C-oil percentage and collapsible potential.

Table 1 shows a summary of the above-mentioned literature related to the improvement of gypsum soils using petroleum materials and their derivatives, as it can be considered as a reference for researchers to know the geotechnical behavior of petroleum-treated gypsum soils.

Table 2: summery of previous works related with the improvement of gypsum soils using petroleum materials

Ref.	Stabilizer agents	Tested parameters	Results
[10] & [9]	F-oil	Permeability	Utilizing fuel-oil caused a reduction in coefficient of permeability.
[11] & [16]	F-oil	Permeability, stability & compressibility	Fuel-oil controlled the collapsibility potential, reduced permeability, and gave a significant result for compressibility test.
[12], [25] & [26]	LA	Permeability, uniaxial compressive resistance, elastic characteristics, and total strain	Liquid asphalt made a significant modification in all mentioned tested parameters of soil.
[13], [14], & [15]	LA	Most geotechnical characteristics	As liquid asphalt content increased, the values of Atterberg limits, specific gravity, maximum unit weight, and collapse potential reduced, while the values of optimum moisture content, California Bearing Ratio, direct shear parameters, uniaxial compressive resistance, improved.
[23]	F-oil	Most geotechnical characteristics for soaked &unsoaked soil.	As fuel-oil content increased in both of soaked &unsoaked soil, the values of specific gravity, maximum unit weight, and collapse potential reduced, while the values of direct shear parameters, uniaxial compressive resistance, improved. In general, the geotechnical behavior for soaked soil was better

			than unsoaked ones.
[24]	C-oil	Compaction, uniaxial compressive resistance, & stability	Crude- oil made a good modification in all mentioned tested parameters of soil.

* F-oil: fuel-oil, LA: Liquid asphalt, C-oil: crude oil

4.Conclusion:

The effects of oil contamination and its derivatives on gypseous soils were reviewed. C and Ø of gypsum soil decrease when immersed in kerosine. OMC, liquidity, dry unit Wight and specific gravity (Gs) decrease with increasing crude oil content. The settlement increases with increasing content of crude oil. F-oil and liquid asphalt are a good material to improve the gypseous soil. According to [16] using of 3% F-oil for clayey soils and 4% F-oil for sandy soils it is possible for treating the gypseous soil from the collapsibility. And using 6% of crude oil it is the optimum crude oil content for MDD and UCS [24]. It is possible to do future studies to provide more data and information about improving gypsum soils with crude oil or its residues, or evaluating the engineering properties of soils contaminated with crude oil residues.

Greek Symbols	
Ø	Internal friction angle
Abbreviations	
K	Coefficient of permeability
HFO	Heavy fuel oil
C-oil	Crude-oil
Cv	Consolidation indicator
Cc	Compression indicator
Cr	Swelling indicator
Ke	Kerosine

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r	
G-oil	Gasoil
F-oil	Fuel-oil
LA	Liquid asphalt
MC-30	Medium curing cutback bitumen
OMC	Optimum moisture content
MDD	Maximum dry density
UCS	Unconfined compressive strength
C	Cohesiveness
DD	Dry density
MC	Moisture content
Gs	Specific gravity

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First, confirm that you have the correct template for your paper size. This template has been tailored for output on the US-letter paper size. If you are using A4-sized paper, please close this template and download the file for A4 paper format called "CPS_A4_format".

Maintaining the Integrity of the Specifications

The template is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them. You may note peculiarities. For example, the head margin in this template measures proportionately more than is customary. This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations.

Prepare Your Paper Before Styling

Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

Units

- Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as “3.5-inch disk drive”.
- Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.
- Do not mix complete spellings and abbreviations of units: “Wb/m2” or “webers per square meter”, not “webers/m2”. Spell out units when they appear in text: “. . . a few henries”, not “. . . a few H”.
- Use a zero before decimal points: “0.25”, not “.25”.

Equations

The equations are an exception to the prescribed specifications of this template. You will need to determine whether or not your equation should be typed using either the Times New Roman or the Symbol font (please no other font). To create multileveled equations, it may be necessary to treat the equation as a graphic and insert it into the text after your paper is styled.

Number equations consecutively. Equation numbers, within parentheses, are to position flush right, as in (1), using a right tab stop. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in

Note that the equation is centered using a center tab stop. Be sure that the symbols in your equation have been defined before or immediately following the equation. Use “(1)”, not “Eq. (1)” or “equation (1)”, except at the beginning of a sentence: “Equation (1) is . . .”

Some Common Mistakes

- The word “data” is plural, not singular.
- The subscript for the permeability of vacuum □$_0$, and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o”.
- In American English, commas, semi-/colons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A

parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)

- A graph within a graph is an “inset”, not an “insert”. The word alternatively is preferred to the word “alternately” (unless you really mean something that alternates).
- Do not use the word “essentially” to mean “approximately” or “effectively”.
- In your paper title, if the words “that uses” can accurately replace the word “using”, capitalize the “u”; if not, keep using lower-cased.
- Be aware of the different meanings of the homophones “affect” and “effect”, “complement” and “compliment”, “discreet” and “discrete”, “principal” and “principle”.
- Do not confuse “imply” and “infer”.
- The prefix “non” is not a word; it should be joined to the word it modifies, usually without a hyphen.
- There is no period after the “et” in the Latin abbreviation “et al.”.
- The abbreviation “i.e.” means “that is”, and the abbreviation “e.g.” means “for example”.

An excellent style manual for science writers is [7].

Using the Template

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper.

Authors and Affiliations

The template is designed so that author affiliations are not repeated each time for multiple authors of the same affiliation. Please keep your affiliations as succinct as possible (for example, do not differentiate among departments of the same organization). This template was designed for two affiliations.

For author/s of only one affiliation (Heading 3): To change the default, adjust the template as follows.

Selection (Heading 4): Highlight all author and affiliation lines.

Change number of columns: Select Format >

Columns >Presets > One Column.

Deletion: Delete the author and affiliation lines for the second affiliation.

For author/s of more than two affiliations: To change the default, adjust the template as follows.

Selection: Highlight all author and affiliation lines.

Change number of columns: Select Format >

Columns > Presets > One Column.

Highlight author and affiliation lines of affiliation 1 and copy this selection.

Formatting: Insert one hard return immediately after the last character of the last affiliation line. Then paste the copy of affiliation 1. Repeat as necessary for each additional affiliation.

Reassign number of columns: Place your cursor to the right of the last character of the last affiliation line of an even numbered affiliation (e.g., if there are five affiliations, place your cursor at end of fourth affiliation). Drag the cursor up to highlight all of the above author and affiliation lines. Go to Format > Columns and select "2 Columns". If you have an odd number of affiliations, the final affiliation will be centered on the page; all previous will be in two columns.

Identify the Headings

Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is "Heading 5". Use "figure caption" for your Figure captions, and "table head" for your table title. Run-in heads, such as "Abstract", will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced. Styles named "Heading 1", "Heading 2", "Heading 3", and "Heading 4" are prescribed.

Figures and Tables

Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation "Fig. 1", even at the beginning of a sentence.

https://doi.org/10.17762/msea.v-i-.-

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity “Magnetization”, or “Magnetization, M”, not just “M”. If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write “Magnetization (A/m)” or “Magnetization {A[m(1)]}”, not just “A/m”. Do not label axes with a ratio of quantities and units. For example, write “Temperature (K)”, not “Temperature/K”.

Footnotes

Use footnotes sparingly (or not at all) and place them at the bottom of the column on the page on which they are referenced. Use Times 8-point type, single-spaced. To help your readers, avoid using footnotes altogether and include necessary peripheral observations in the text (within parentheses, if you prefer, as in this sentence).

Copyright Forms and Reprint Orders

You must submit the Copyright Form per Step 7 of the CPS author kit’s web page. THIS FORM MUST BE SUBMITTED IN ORDER TO PUBLISH YOUR PAPER.

Please see Step 9 for ordering reprints of your paper. Reprints may be ordered using the form provided as <reprint.doc> or <reprint.pdf>.

Acknowledgment

The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression, “One of us (R.B.G.) thanks . . .” Instead, try “R.B.G. thanks”. Put applicable sponsor acknowledgments here; DO NOT place them on the first page of your paper or as a footnote.

References

List and number all bibliographical references in 9-point Times, single-spaced, at the end of your paper. When referenced in the text, enclose the citation number in square brackets, for example [1]. Where appropriate, include the name(s) of editors of referenced books. The template will number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use “Ref. [3]” or “reference [3]” except at the beginning of a sentence: “Reference [3] was the first . . .”

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the reference list. Use letters for table footnotes.

Unless there are six authors or more give all authors’ names; do not use “et al.”. Papers that have not been published, even if they have been submitted for publication, should be cited as "unpublished" [4]. Papers that have been accepted for publication should be cited as "in press" [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [6].

[28] G. Eason, B. Noble, and I. N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*

[29] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[30] I. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

[31] K. Elissa, "Title of paper if known," unpublished.

[32] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[33] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[34] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[35] Electronic Publication: Digital Object Identifiers (DOIs):

[36] D. Kornack and P. Rakic, "Cell Proliferation without Neurogenesis in Adult Primate Neocortex," Science, vol. 294, Dec. 2001, pp. 2127-2130, doi:10.1126/science.1065467.

[37] H. Goto, Y. Hasegawa, and M. Tanaka, "Efficient Scheduling Focusing on the Duality of MPL Representatives," Proc. IEEE Symp. Computational Intelligence in Scheduling (SCIS 07), IEEE Press, Dec. 2007, pp. 57-64, doi:10.1109/SCIS.2007.357670.