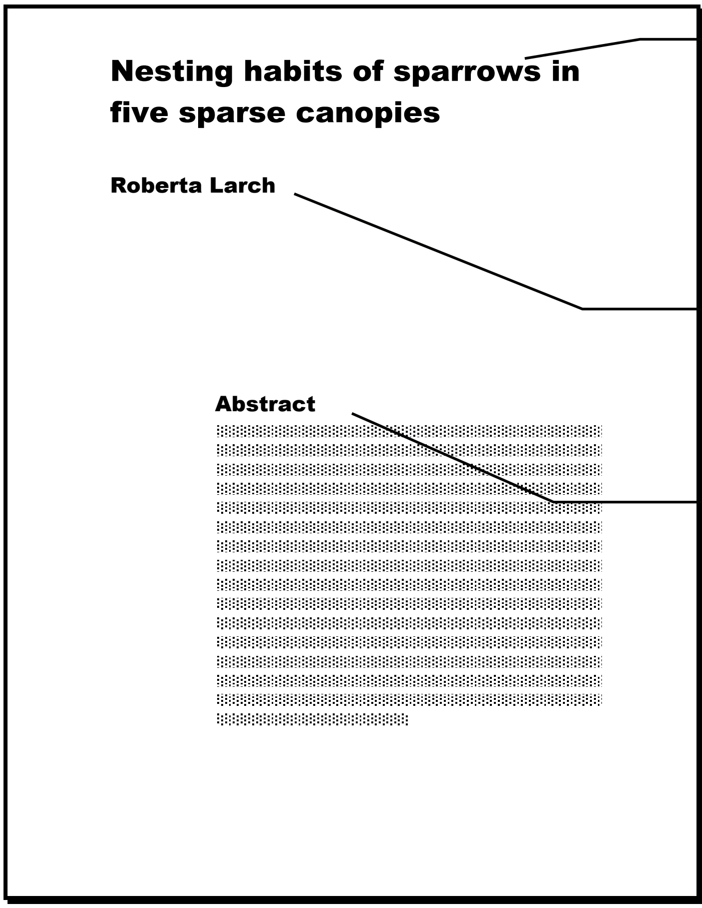
Anatomy of a Research Report—Part I



Write a descriptive title that names the subject, the independent variables, and the dependent variables.

Put the author's name beneath the title.

The abstract is a type of summary. Use what is called an "informative abstract." You pull core ideas from each section of your paper and place them in the abstract, so that an expert could read the abstract and get the big picture. Because the abstract summarizes your paper, write it last (after you've written what you are summarizing). Briefly state the background, purpose, and scope. State your hypothesis, your dependent variables (what you measured) and your independent variables (what you varied). State what you found (your conclusions). If you have recommendations, state them as well. But be BRIEF: the abstract is usually fewer than 150 words.

1. What is the title of your paper?
2. Write the basic elements of your abstract here:
    - background:
    - purpose:
    - scope:
    - dependent variables:
    - independent variables:
    - conclusions:
    - recommendations:

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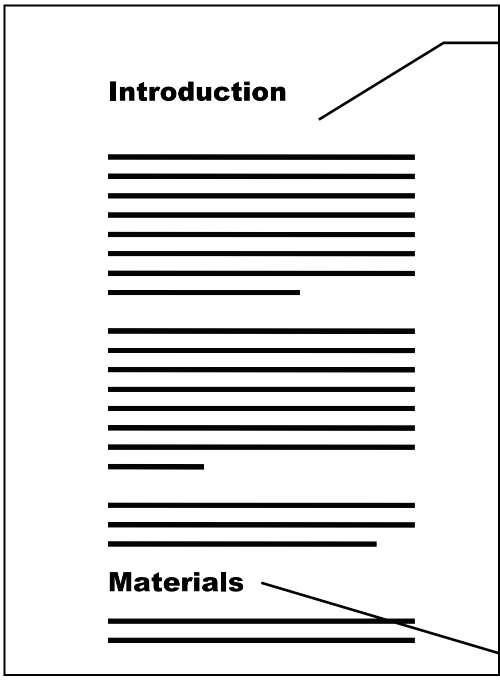


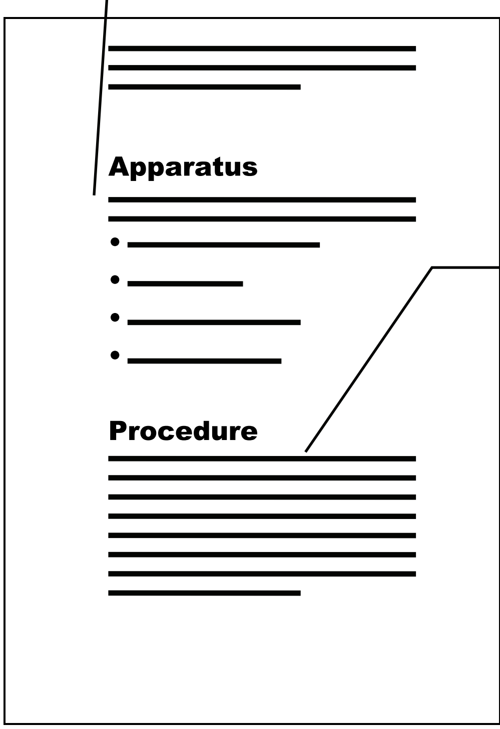
The introduction orients and prepares the reader to understand the rest of the paper. It should cover the following topics, not necessarily in this order:

- Purpose: the objective of the research. Tell in one or two sentences what the research should do or what it should tell people.
- Problem: closely tied to purpose. What is the problem that created the need to do the research? Reader must understand the problem before she/he can understand the solution.
- Scope: limitations. Settles all doubts about what the report will cover and what it will leave unresearched. Also may touch briefly upon your qualifications to study this problem.
- Background information. Generally in the form of a literature review—review of previous, related research. Gives readers the grounding they need to understand the research.
- May have definitions, conventions for the paper, symbols, and may warn of any other non-standard elements of your paper.

If you have raw materials that don't count as equipment, then list them here. For example, how much of a certain chemical did you use? How much rope? How many rolls of film?

For this section and the next, you may use lists. However, always place some introductory text between the heading and the list—a list cannot stand on its own.

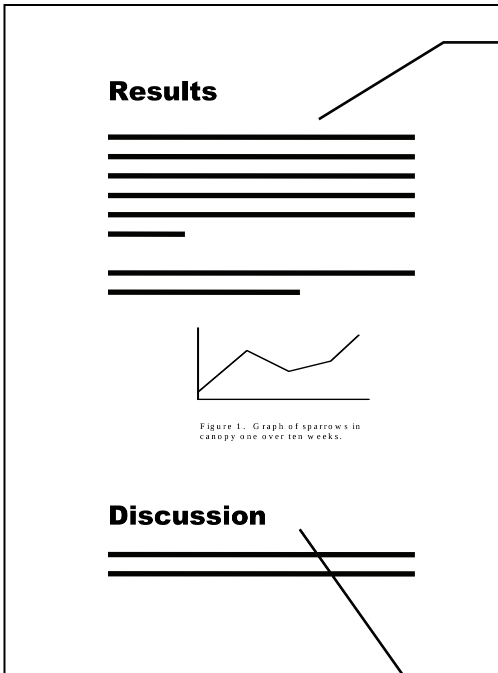
The apparatus section list any equipment or tools you used. If you are writing about human test subjects, you will probably list them in the previous section.
If you are working on software development, use this section to describe the software environment.



Do not write the procedure as you would write instructions. Describe the procedure as if you've already completed it. Passive voice is often used, but active voice (in this case, first person) is acceptable in some fields. Another engineer or scientist must be able to duplicate your work from your description, so be complete and accurate. Include the following kinds of details:

- conditions of test
- length of test
- how observations were made
- what you held constant and how
- what you varied and how
- special precautions
- troubles encountered
- safety considerations
- methodology philosophy—why was this method chosen?

Anatomy of a Research Report—Part II



Everything before the Results section explains why you wanted data and how you got data. Everything after the Results section will explain what the data mean. Therefore, the data in the Results section are the core of the paper.

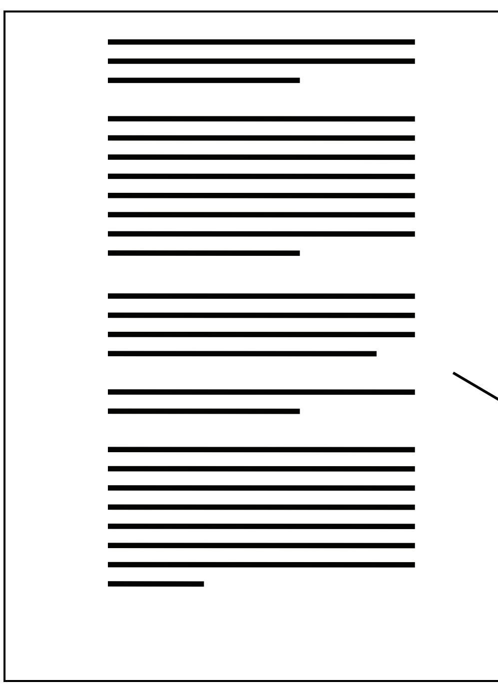
- Only the facts—no interpretations.
- Figures and tables—all appropriately labeled.
- Calculations if necessary.
- Point out the main idea in the results and in each figure or table—but don't interpret!
- If you have more than one figure or table, then place informative text between the figures and/or tables as transitions.

The results section shows the reader the data you collected in a format that is easy to read. Data are easy to read when they are grouped into succinct packets: each graph or table should convey only one or two sets of relationships among the dependent and independent variables.

The Discussion of the results tells the reader what the results mean—this is where you interpret. For example, were some results higher than you expected? Point out this surprise here, and try to explain *why* you think the results were high. Were some results contradictory? If so, make sure the reader sees the problem. This section can perform many functions:

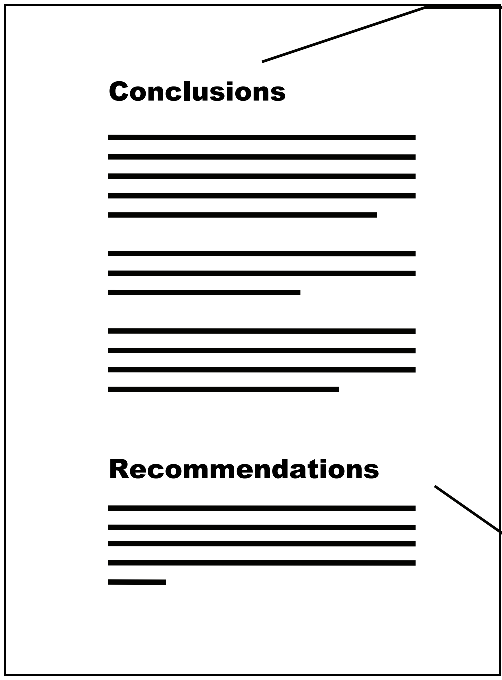
- Evaluate and interpret all facts
- Qualify or limit results to special circumstances
- Discuss sources of error
- Recognize unexpected results and try to account for them

Your discussion treats the facts of the results section as if they were objects that you were inspecting. You may even use more figures or tables here if they display *interpretations*: data you have manipulated somehow.



Notice how long the Discussion section is. You can get very detailed here. However, don't go on and on needlessly: interpret the data thoroughly yet concisely.

Anatomy of a Research Report—Part III



In the Conclusions section, you tell the reader what you decided about the hypothesis, about the problem that inspired the research, and about the way you handled the experiment. In other words, what did you *conclude* after all your work?

Label this section “Conclusions,” not “Conclusion.”

Arrive at your conclusions using formal reasoning: either inductive logic or deductive logic. Inductive logic is bottom-up, while deductive logic is top-down.

Your conclusions must follow logically from the interpretations of facts that you wrote in the Discussion section.

The Recommendations section is where you give advice to the reader. In other words, what would you do differently next time? What is the next step in research? What actions in the real world does your research support?

Research Report Checklist

Title Page

____ Abstract appears beneath title of the report.

____ Abstract is titled “Abstract.”

____ In 150 words or fewer, the descriptive abstract summarizes the purpose, scope, and methods of the experiment; in 250 words or fewer, the informative abstract summarizes the purpose, scope, methods, conclusions, and recommendations.

Introduction

____ Explanation of problem or question that inspired the research (may include references to previous research).

____ Explanation of specific purpose or objective(s) of the research.

____ Scope. Settles all doubts about what report will cover or not cover. May be included in purpose.

Materials/Equipment/Software Environment

____ All necessary items included.

____ Includes a drawing of items that are difficult to describe verbally.

____ List format used to enhance readability.

____ Definitions and/or descriptions included where necessary.

Procedure

____ Written in proper verb form, according to your instructor or the targeted publication.

____ Sequential.

____ Clear and complete enough for reader to replicate.

Results

____ Graphic aids used to enhance readability.

____ Significant findings are pointed out, but not interpreted (interpretation is in discussion and conclusions).

Discussion

____ Interprets and evaluates individual results and trends.

____ Discusses possible sources of error.

____ Recognizes unexpected results and tries to account for them.

Conclusions

____ Follows logically from discussion.

____ Connects discussion back to research objective and the problem that inspired the research.

____ Takes into account all results.

Recommendations

____ Recommendations for improved research, based on Conclusions.

____ Recommendations for expanded research, based on Conclusions.

Appendix

____ Software code.

____ Results too detailed for the main Results section.

Tables and Graphs

____ Numbered and titled in the right place.

____ Surrounded by sufficient white space.

____ Information is displayed as simply and clearly as possible.

____ Text contains references to the tables and graphs.

____ Tables and graphs placed close to textual references.

____ Graphs include unit labels for both axes.

Overall

____ Report has headings.

____ Numbers are used correctly.

____ Report is free from grammar, spelling, and punctuation errors.

The Effect of Curing Time on the Strength of Aggregate Concrete

Author(s) Name

Abstract

The collapse of Buzzard Creek Bridge on June 15, 2006, brought about the need to find a new and stronger mixture of concrete. A particular mix was proposed and research was done to determine the strength of that concrete over the span of 28 days of curing. A hand-mixed sample of this concrete was carefully prepared and cured over the course of 28 days, two cylinders being tested for strength every 7 days. An error in handling rendered the data of one cylinder inaccurate, but the remaining data clearly reflected that the strength was sufficient to meet the 5,000 psi demand on the bridge. It is suggested that further experiments regarding the effect of temperature and wear on the strength be performed in order to best care for the concrete after building. However, the results of the experiment show that the mixture has the strength required for this structure, and it is therefore recommended as the building material for the structure.

Introduction

In June 2006, the Buzzard Creek Bridge collapsed as a result of a weak support structure caused by the particular mixture of concrete used to build the supports. In order to rebuild this bridge, a new mixture of concrete must be found that can withstand the 5,000 pounds per square inch of pressure that is estimated as the load weight of the bridge.

The study that follows is an undertaking of this problem. This study of the compressive strength of this mixture of concrete is intended to determine the feasibility of its use in the rebuilding of this bridge, as well as possible other structures in the future. Since concrete strengthens as it cures, the result of an experiment taken over time will give continuous data that can be used to predict the strength over time, as well as the maximum attainable strength.

The specific objective of this research is to determine the strength of this specific mixture of concrete, cured at 70° F, over a variable length of time. This mixture is expected to be able to withstand at least 5,000 psi after 28 days of curing.

Materials

Table 1 includes the list of ingredients used in the tested mixture of concrete.

Table 1: Ingredients in Concrete Mixture

	To Yield:	
Ingredient	Cubic Yard	Cubic Foot
Cement	775 lbs	28.7 lbs
Water	340 lbs	12.6 lbs
Fine Aggregate	1140 lbs	42.2 lbs
Coarse Aggregate	1680 lbs	62.2 lbs
Total Weight	3935 lbs	145.7 lbs

Apparatus

The equipment used to create and test the concrete was:

- Mixing tub
- Hoe
- 8 oiled cylindrical molds (top surface area of 23.7 inches)
- Curing room
- Tinium Olsen testing machine (serial number 89377, capacity 400,000 lbs)

Procedure

The first concern of this experiment was ensuring the proper mixture of concrete. Using care, the proper amounts of each ingredient were thoroughly mixed together, resulting in an accurate sample of concrete to be tested. The mixing was all done by hand using a mixing tub and hoe.

The mixture was poured into 8 oiled cylindrical molds, tamping three times while pouring thereby creating an air-free sample on which the compressive strength could be studied. This method of casting ensures less air contaminating the sample, and thus a stronger mixture of concrete. In the curing room, the concrete was placed on its side and moist cured in order to prevent drying out and to allow for greater strength in the concrete itself. The temperature was kept at 70° F with 100% relative humidity while curing, as per ASTM standards. These steps produced a consistent sample of concrete to be tested under different conditions.

Over the course of 28 days, two cylinders of concrete were tested every 7 days, beginning on the 7th day after mixing. The conditions for the test itself included a variable temperature, between 66° F and 72° F, depending on the outside temperature. The concrete was tested by the steady application of increasing pressure until the rupture point, using a Tinium Olsen testing machine with a capacity of 400,000 pounds. This rupture point was recorded as the maximum compressive strength of the concrete after that length of curing. Since it is known that the strength of concrete increases over time, the measurement of the strength over a series of days allows for a greater understanding of the trend of the data, as well as a better method for prediction of the indefinite future. Also, for accuracy of data and examination of variables, the temperature was measured at the time of testing.

The primary difficulty in this process is the handling of the cylinders. After casting, it is essential to ensure stability and careful handling in order to avoid contaminating the concrete with air or causing the concrete to set incorrectly. The handling that must occur should be minimal, as it can greatly affect the integrity of the concrete and therefore the results of the experiment. This difficulty was encountered in this experiment when cylinder #8 was jarred while being moved to the curing room. The data reflects the inconsistency that results from such an error in procedure.

Results

The figure below represents the relationship between the strength of the concrete and the length of time it was cured, using the average strength of the cylinders on each day.

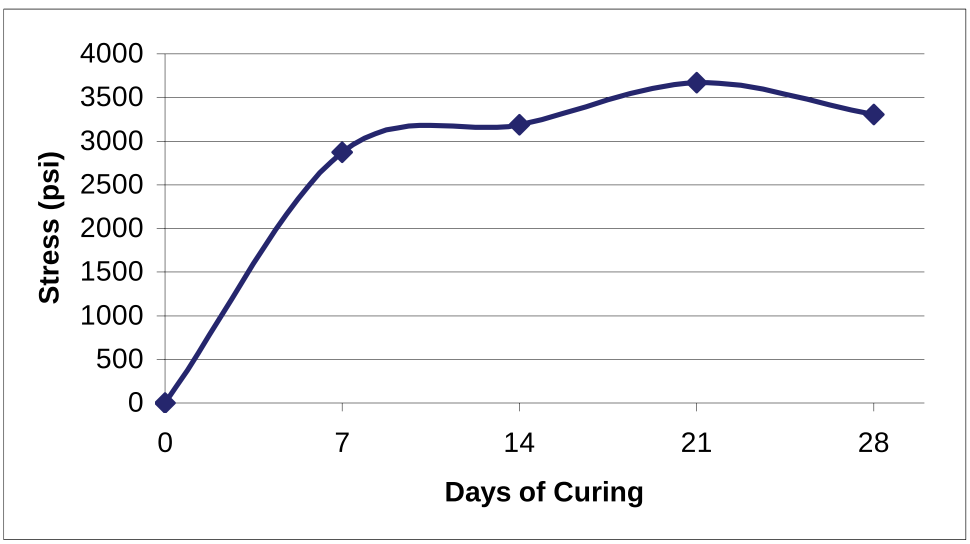


Figure 1: Change in Stress Limit Across 28 Days of Curing

The exact numerical data represented in Figure 1 is shown in Table 2, as well as the mean and standard deviation of each set of cylinders.

Table 2: Results of Stress Test on Concrete Mix

Days	Cyl. #	Temp	Stress	Mean	Stand Dev
7	1	72	2840	2875	49.50
	2	72	2910		
14	3	70	3230	3190	56.57
	4	70	3150		
21	5	70	3650	3672.5	31.82
	6	70	3695		
28	7	66	5030	3305	2439.52
	8	66	1580		

Temperature was the only variable testing condition, and the values of this variable are related in Table 2. Further, the relationship of temperature to days of curing can be found in Figure 2.

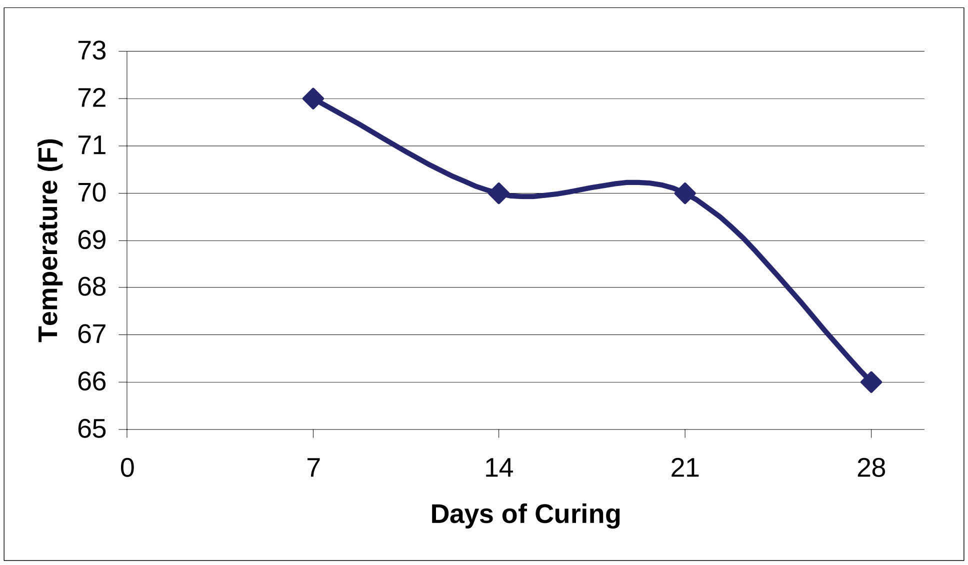


Figure 2: Temperature on Days that Strength was Tested

Discussion

In order to accurately interpret the results, an understanding of the inconsistent aspects of the data must be found. It is known from previous experiments that concrete strengthens as it cures, yet the data represented in this experiment does not reflect this fully. The data taken after 28 days of curing does not reflect this trend. In order to take into account this data, the error in procedure must first be assessed.

The jarring of cylinder 8 clearly had a detrimental effect on its strength. While the rest of the data follows an upward curve, this single value does not fit with the data. Further, the high standard deviation indicates that the strengths of cylinders 7 and 8 are drastically different. Typically, this is an indication of a problem in the experiment. Since it is known that experimental error occurred while dealing with cylinder 8, the data from this cylinder is best disregarded. By disregarding the data from this cylinder, a clear and smoothly increasing graph is created, much more representative of the logarithmic strength that would be expected from a mixture of concrete. This revised graph can be found in Figure 3.

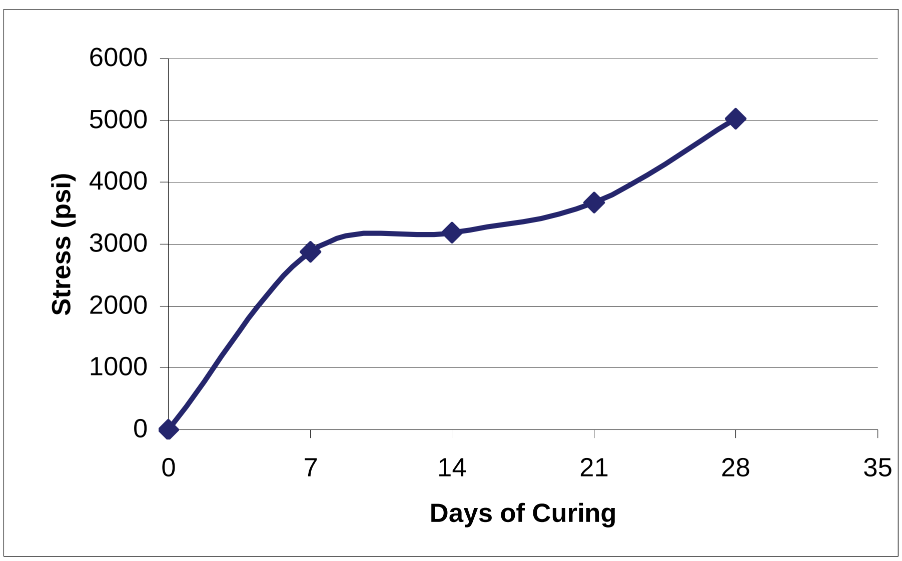


Figure 3: Revised- Change in Stress Limit Across 28 Days of Curing

This data reflects strength of over 5,000 psi after 28 days, indicating the validity of the hypothesis.

The effect of temperature on the strength of the concrete is something that must further be examined. The figure of temperature over length of time is reflective of a contrasting relationship between temperature and strength. However, the current room temperature has little to no effect on the strength of concrete. Rather, it is the temperature at which it was cured that plays an important role in this strength. The constant nature of the curing temperature ensured that there were no noticeable effects from the temperature on the strength of the mixture. While the surrounding temperature during testing might have had a small effect, this can be disregarded because of its non-essential role in the strength of the mixture. While this might have influenced the data slightly, serving as a cause of error, it was not sufficiently important to sway the overall results of the experiment.

The data from this experiment is reflective of the strength of this concrete under the conditions given. In order to assure the strength that is shown in the results of this procedure, similar steps must be taken. It is primarily important to cure the mixture for at least 28 days before exposing it to extreme pressures.

Conclusions

The results of this experiment support the hypothesis that this mixture of concrete can withstand 5,000 psi after 28 days of curing. The graphed results of strength over time display the increasing strength of this mixture as length of curing time increases. Both the exact data and the best-fit line indicate a final compressive strength of over 5,000 psi. This final strength is the most essential data, and it reflects the desired strength.

The concrete mixture studied is, as a result of this strength, an excellent choice for the rebuilding of Buzzard Creek Bridge. The strength it offers is sufficient, and the length of time it takes to achieve this strength is reasonable. To be successful, the mixture must be cured for at least 28 days prior to being exposed to great pressure. If this procedure is followed, however, the concrete will work well for its intended purpose.

Recommendations

It is suggested that further experimentation be done to better care for the concrete, ensuring longevity and continued strength. The effects of temperature, weather, and other adverse conditions on this mixture were not studied and will necessarily have an effect on the continued strength of the concrete. Further research on the best care for the concrete as well as the expected lifespan of the mixture will help to prevent a similar disaster in the future.