THE DESIGN OF A HYDRAULICS LABORATORY FOR MICHIGAN STATE COLLEGE

Thesis for the Degree of B. S.

MICHIGAN STATE COLLEGE
E. Q. Moulton

1947

The Design of A Hydraulics Laboratory for Michigan State College

A Thesis Submitted to

The Faculty of

MICHIGAN STATE COLLEGE

of

AGRICULTURE AND APPLIED SCIENCE

by

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Candidate for the Degree of

Bachelor of Science

June 1947

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ACKNOWLEDGEMENTS

The author wishes to take this opportunity to extend his sincerest thanks to Professor C. M. Cade for his ever-readyness to supply suggestions and information, the Michigan State College librarians for their interest in obtaining the required texts, and last but not least, Professor C. L. Allen for his cooperation and undieing zeal, which were all of great aid in the research, compiling, and writing of this thesis.

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CHAPTER I: INTRODUCTION

Michigan State College school of engineering was founded in 1855. At this time it was the object of the educators to inaugurate an inexpensive engineering school. Ever since then M. S. C. has been gradually building itself a reputation in this field.

At the present time it is the author's opinion although this school has been improving in the past, it has reached its peak and unless several steps are taken immediately a decline will begin to take place. The crux of this situation lies more in the practical aspect of the educational system rather than the theoretical. Coming directly to the point, practically all the engineering laboratories at Michigan State College are inadequate and out moded.

It is fairly apparent that M. S. C. graduates will find their knowledge inferior when placed along side a graduate from a school which has modern equipment and methods in their laboratory.

In order to right these short comings, the Michigan State College controlling board, Michigan State Board of

Agriculture has made plans for the construction of several new engineering buildings. Large floor areas have been set aside for the assembling of ultra-modern laboratories. These are not only to be used for undergraduate exercises, but also by the graduates for research. One of these structures designed to relieve the strain on Olds Hall and build up the engineering school, is the Civil Engineering building devoted soley to the instruction of subjects pretaining to this field.

The author has choosen for his undergraduate thesis the design of a labortory for this new building which concentrates on the subjects of hydraulics and fluid mechanics.

In reading further in this article, it must be remembered that although M. S. C. does have a hydraulics laboratory, it contains only the essentials necessary for a basic study of hydraulics alone. And since Michigan State College in the past has offered no courses pretaining to fluid mechanics, it has no facilities for a course of this nature. It must also be remembered that there has been very little research done at Michigan State College pretaining to either hydraulics or fluid mechanics.

What the author proposes is a design of a laboratory that would adequately clarify points brought out in the lectures and at the same time provide facilities for research work in graduate school. Since such a laboratory is quite new to our college it is relatively difficult to ascertain just what might be needed. In making an intelligent study of this pro-

blem it can be seen that much time, money, and disapointment would be saved by simply consulting other universities which were once confronted with the same problem and solved it effectively.

This is to be the chief source of information used in the compiling and writing of this thesis.

The first step taken was the writing of a letter to seek as much information as possible and where practical visit such laboratories. The following letter was composed and sent for this purpose.

April 2, 1947

Dear Sirs:

Under the new expansion program, Michigan State College has made plans for the construction of a new building devoted soley to the study of civil engineering subjects. In this building there has been a laboratory set aside for undergraduate study and also graduate research in the field of hydraulics. Since a laboratory of this nature is relatively new to our school. I have been assigned for my undergraduate thesis the problem of tentatively planning a layout and suggesting equipment that might be used to study effectively and do further research in this field.

To do this matter justice I feel that the only way to start is by finding out just what equipment has been successfully employed at the universities that are the leaders in hydraulics. This is why I am writing you.

Any information that you may supply me as to the layout of your hydraulics laboratory, the equipment used, its use, and how effective it is, will be greatly appreciated and properly used in the solution of our task.

Sincerely,

Edward Quentin Moulton

After giving due consideration to all the leaders in the hydraulic field, the preceding letter was sent to the following universities:

Massachusetts Institute of Technology
Iowa Institute of Hydraulic Research
California Institute of Technology
University of Tennessee
United States Naval Academy

In the following chapters a summary of the data received will be discussed.

Feeling the information these schools might remit would be rather incomplete and inadequate, the author made plans to visit any hydraulics laboratory that is within reasonable range of East Lansing. There were two such schools, the University of Michigan and the General Motors Institute of Technology.

These labs were visited and data collected to help further in making an intelligent study of my task.

At this time it should be pointed out that it is not the plan of the author to pattern the laboratory after any one

particular school but to take advantage of all the outstanding features from each and incorporate them into one ultra-modern design to suit not only our present day need but also to arrange a laboratory in such a manner that with slight alterations it could be kept modern for forty years to come.

CHAPTER II: SOURCES OF INFORMATION

In summarizing the information obtained the author will start with the sources spoken of in Chapter one. This information was obtained from four of the five universities written. The first reply was from the Iowa Institute of Hydraulic Research at Iowa City, Iowa. It was as follows:

April 10, 1947

Mr. Edward Q. Moulton
Civil Engineering Dept.
Michigan State College
East Lansing, Michigan

Dear Mr. Moulton:

We are sending you herewith a bulletin describing the research facilities of the Iowa Institute, which we believe will provide the information requested in you letter of April 3.

Very truly yours,

Hunter Rouse
Director

HR?lma

The enclosure was of great aid in providing the needed data. Although their laboratory is on a far greater scale than the one proposed for M. S. C. still it contained many

useful ideas.

The second letter returned was from Massachusetts Institute of Technology.

April 12, 1947

Mr. Edward Q. Moulton
Civil Engineering Department
Michigan State College
East Lansing, Michigan

Dear Mr. Moulton:

Your letter of April 3 concerning the planning of a new hydraulic laboratory has been referred to me. Since we are engaged ourselves at present, in planning a new hydrodynamics laboratory and since our present layout could not very well serve as a model for a new one, I am not able to supply you at present with the information you desire. While we do have a considerable amount of equipment, we have no material available of a descriptive nature, which we could furnish you. I would suggest as the best way of getting the information you desire that you the various leading hydraulic laboratories of the country, such as the Iowa Institute of Hydraulic Research at Iowa City, Iowa, and the St. Anthony Falls Hydraulic Laboratory in Minneapolis. Needless to say we should welcome to show you our facilities here and to show you whatever plans are completed up to the time of your prospective visit.

Sincerely yours,

Arthur T. Ipen

ati:mjj Associate professor of Hydraulics

Needless to say this was of no aid.

The third to reply was the University of Tennessee.

April 11, 1947

Mr. Edward Quentin Moulton

Cilil Engineering Department

East Lansing, Michigan

Dear Mr. Moulton:

I have your letter with regard to plans and equipment in our hydraulics laboratory. We do not have a drawing showing the equipment, but I expect to have one prepared in two or three weeks and will send you a copy at that time and will also send the list of equipment. I would recommend that you refer to an article in the Proceedings of the Boston Society of Civil Engineering, in which descriptions are given of most of the larger laboratories in the United States. Our laboratory does not happen to be included in the descriptions, although I think it would be classed as one of the better and larger ones.

Very truly yours,

Cecil S. Camp, Associate Professor

CSC:mjm Hydraulic and Sanitary Engineering

At the time of writing this chapter no information has yet been forwarded with regard to a bulletin of such a nature, but the reference mentioned was of great use to the author in

writing this thesis.

Although the Michigan State College library does not have this magazine in their reference stacks and very few libraries in the nation do, an edition was received from the library at Purdue University.

The last reply was from the United States Naval Academy at Annapolis, Maryland.

April 17, 1947

Mr. Edward Q. Moulton
Civil Engineering Department
Michigan State College
East Lansing, Michigan

Dear Sir:

In reply to your letter of April 3, 1947 regarding the Naval Academy laboratory equipment employed in conjunction with our course in Fluid Mechanics, the following information is submitted:

(a) The course is really basic Fluid Mechanics; and Hydraulics, as such, is not emphasized.

(b) The laboratory equipment is designed to emphasize fundamentals studied in the course, with particular effort to employ the simplest equipment possible. In other words, we strive to present the material in such a way that there can be no doubt in the student's mind that the results as obtained are really correct.

(c) Enclosures are forwarded to give you a better idea of the objective of each laboratory exercise, and a brief description of equipment.

I trust that this information is satisfactory. If further information is desired do not hesitate to request it.

Very truly yours

C. S. Seabring
Captain, U. S. N.
Head of Department of Marine Engineering

Encls.

Much detailed data was obtained from this source. The enclosure was a complete set of laboratory reports the students perform in their course in fluid mechanics.

California Institute of Technology was not heard from. These are the references used in writing this report. Although this list may seem rather inadequate in length it must be remembered that the one article contains approximately one hundred laboratory descriptions.

The field trip previously spoken of to G. M. Tech. was arranged and taken in the middle of April. The hydraulics laboratory was rather a suprise to the author and further mention of it probably would not be made except for the fact that some ideas were gained. The laboratory itself consists entirely of hydraulically operated machines with no fundamentals being illustrated, but more the ability to repair taking the spotlight. These few ideas will be brought in later with respect to hydraulic pressures. Later the Uni-

versity of Michigan's Fluid Mechanics laboratory was also visited and some applicable ideas were obtained there. For the most part, though, their laboratory resembled ours at State.

The above data combined with a complete study of Michigan State College laboratory is the source of my information.

CHAPTER NO III: EQUIPMENT DESIRED

The suggested equipment and design of a new hydraulics laboratory for michigan State College shall be described in this chapter. In reading this, several points must be remembered. Although some of the equipment is easily described, much will be rather general. The manufacturers names will not be mentioned and in many cases suggested materials are not in production. Exact dimensions have also been purposely avoided for the simple reason that the size of the laboratory may vary greatly, since the new building has not been designed as yet. What the author wishes to do is more or less convey an over-all picture of what he feels a modern laboratory should contain. In several instances detailed information is supplied.

The source of a constant head by means of a stand-pipe shall be obtained by a one cubic foot per second centrifugal pump pumping from the sub-basement level for greater efficiency. A three inch pipe is connected from this pump directly to the top of the stand-pipe. At this level of the twelve inch stand-pipe there is to be a circular weir in order that the overflow might discharge into the drain well

in the sub-basement. The return also is to be a three inch pipe so that there could be no possibility of overflowing on the roof of the building. This apparatus must be enclosed, allowing no foreign materials to enter the circuit.

On the portion of the stand-pipe which passes through the laboratory, in two vertical rows, are to be placed six orifices. These are to be permanently afixed with water tight coverings insuring no leakage when not in use. The suggested orifices are:

1. Square----------sharp edged
2. Round (contracted)----------sharp edged
3. Round----------rounded approach
4. Short Tube
5. Expanding short tube

The final dimensions of the above should be one square inch in area. Placing in two vertical rows, no two orifices will be closer than one foot.

The second method of supply was the previously spoken of one, two and three cubic feet per second electronic controlled centrifugal pumps, also placed at the sub-basement level in a pumping room, arranged for pump tests. These pumps along with the stand-pipe shall be supplied directly from the Red Cedar River. The river bed drain is to be placed at a level two feet higher than the pump level in order that the siphon will bring the water to the pump room level. A twelve inch pipe should connect these two.

A gate valve must be placed in this circuit so that when

the pumps are not functioning the water will not enter the circuit. A water meter will measure the pumped water.

Now with the initial source extablished the following circuits are to be supplied.

1. Research
2. Normal Head Loss
3. Plastic Head Loss
4. Water Hammer
5. Pipe Friction
6. Jump and Weir

Starting with the research circuit this two inch pipe is to be conveniently located on three of the four walls. The branch will be supplied as the other circuits by any one of the three sources, with an outlet every ten feet, using gate valves. At one such opening the set-up for Reynolds number experiment shall be placed. An illustration of this set-up is shown in figure no. one. Another opening shall be used for an impulse wheel, in a manner illustrated in figure no. two. Watt meters, scales, and a venturi meter shall be used in ascertaining the efficiency of this arrangement.

The second arm is to be a head loss branch. This shall contain:

1. Three gate and three gobe valves in parallel.
2. One disc type and one spinner type water meter placed in series.
3. Two U-bend pipes in series.
4. Two venturi meters.

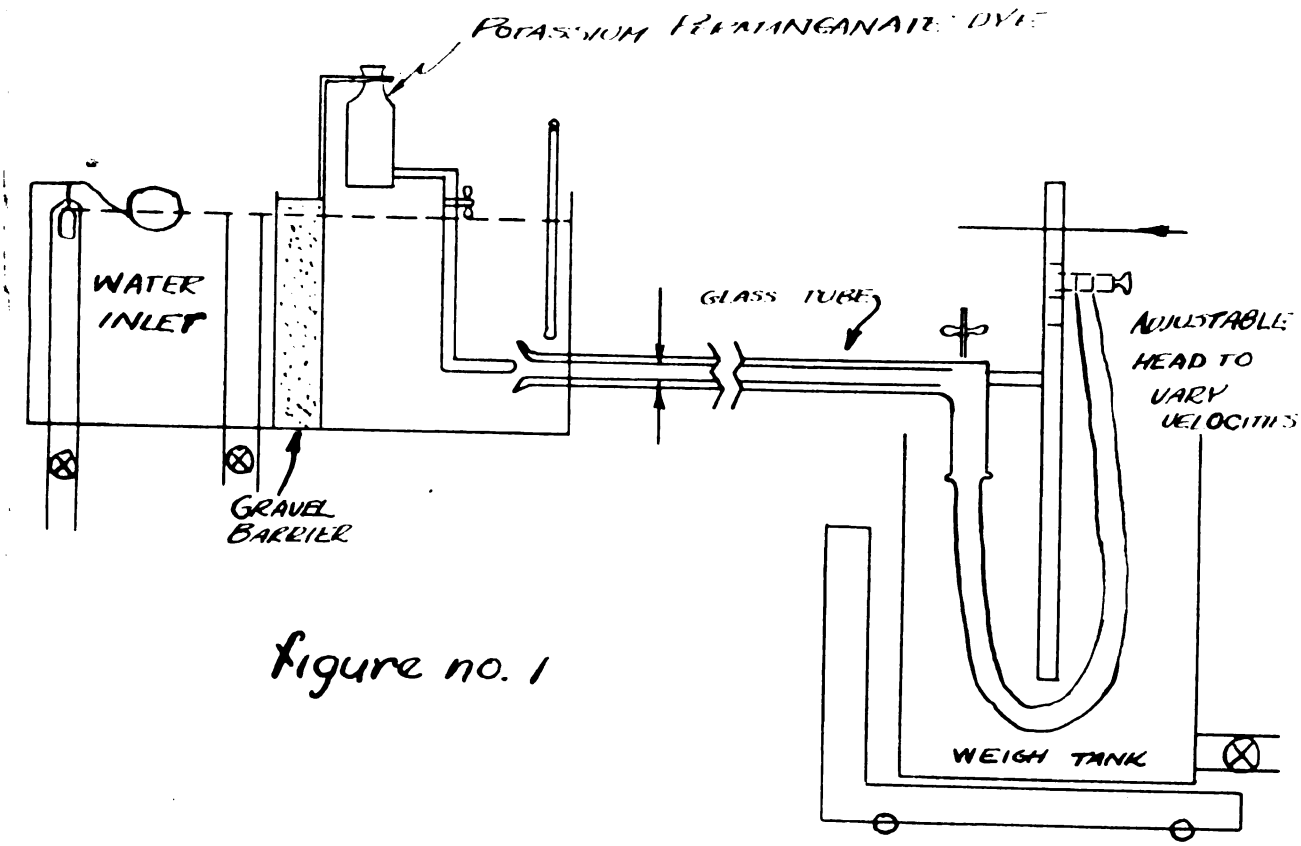

Figure no. 1

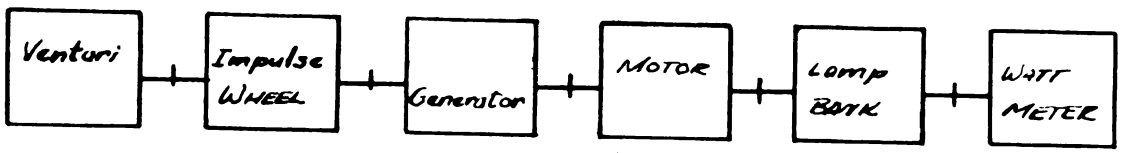

Figure no. 2

5. Three pipe couples.

6. Three T-joints

7. One inch pipe contraction

Between all these connections there should be manometer openings arranged so that pressures may be found. This circuit is to be of two inch pipe. Manometer connections shall be so made that readings shall not be influenced by adjacent experiments.

The third circuit is to be identical except instead of being made out of the normal materials it is to be constructed solely of a transparent material.

The water hammer circuit should be constructed of two inch pipe with quick acting valves at both ends and an auxiliary drain before the first quick acting valve. Scales at the end should be calibrated to measure the forces exerted and a venturi at the source to measure the quantity of water and pressures.

The pipe friction circuit shall consist of a withdrawable friction clamping device. Venturi meters are placed on each side of the space between the two clamps where the pipe to be experimented on is clamped. Special couples must be machined for the ends of each pipe used. The source is from a two inch pipe.

The hydraulic jump is connected in such a manner that the total source may be sent directly to this flume. It's dimensions are three feet wide, four feet high and twenty feet long. An entire thesis could be written on this jump

alone but time does not permit. If any further information is desired, the author refers you to the Boston Society of Civil Engineer's article. The most practical to the author's eyes is the one at California Institute of Technology. The walls of this jump are made of glass or some transparent material and also graduated. A hook gauge is used in determining the head.

At the end of this flume are removeable weirs. Five types are recommended:

1. Proportional Flow
2. Rectangular
3. Triangular
4. Hidden Rectangular
5. Cipoletti

These are to be one square foot in area up to the three foot level. It is further recommended that three replaceable lips be used in the experiment. See figure no. three.

All these circuits are to have grating at their discharge so that the effluent may be measured by the scales or discharged directly in the sub-basement well.

The river is to flow through one end of the laboratory. The flume in which it flows will have a cross-sectional view as shown in figure no. four. There will be gates at both ends to stop the flow when necessary. The sides are to be replaceable with various materials to illustrate the Chezy formula. Also current meters are to be suspended so that a measurement of flow may be taken.

A current meter is to be placed in the middle of the Red Cedar River on a six foot arm which rotates to facilitate a

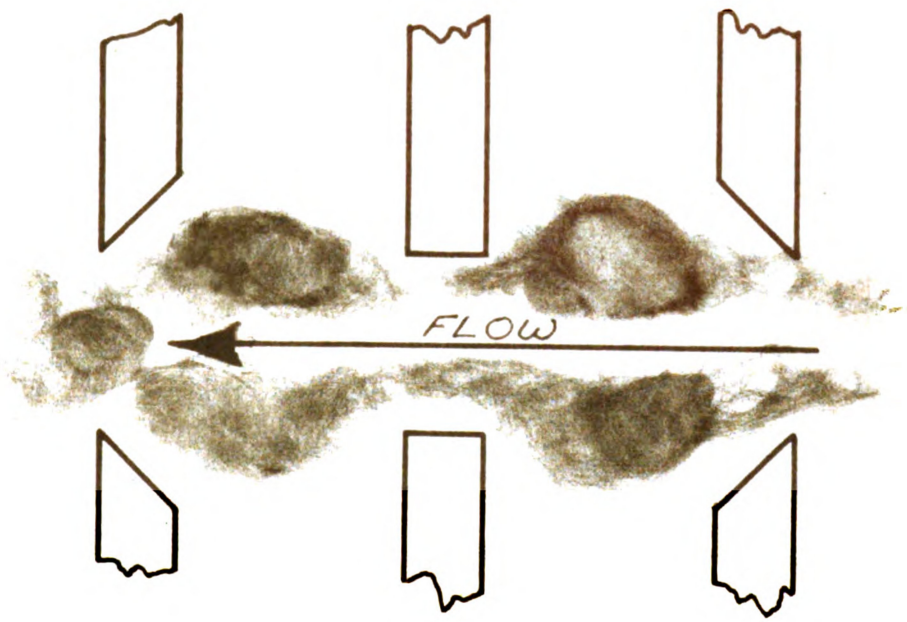

Figure no. 3

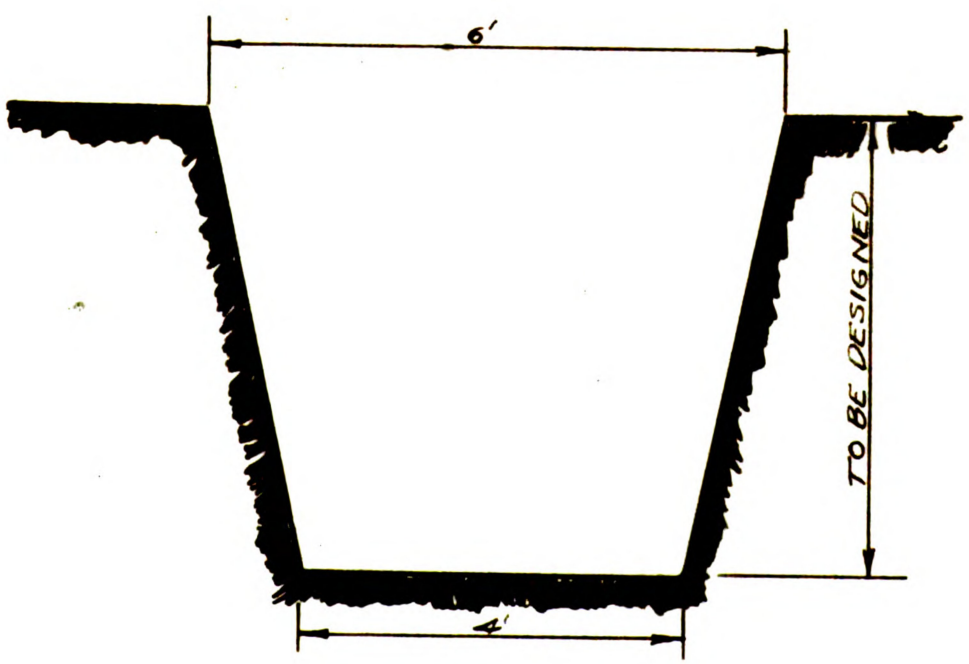

Figure no. 4

a constant flow measurement. The type suggested is used at Rensselaer Polytechnic Institute as shown in the Boston Society of Civil Engineer's article.

A room is to be set aside for calculating, containing computators. In this room a model flow circuit is to be constructed on a minature scale, using abutments, river bends, and various obstrutions. The water will contain aluminum sulphate powder which when projected on a screen by light will show the eddy currents.

An equipment room which contains portable equipment to be used in the lab. such as portable scales, stop watches, current meters, etc..will also be valuable and necessary asset.

In the laboratory there shall be one electric weighing device of one thousand pound capacity, such as the one used at Iowa University, only on a smaller scale which will be more fitting for this lab.

The laboratory is also to be equipped with compressed air.

CHAPTER NO IV: LAYOUT

The general arrangement of the laboratory suggested for Michigan State College is shown on the next page.

Although all items have a definite place, it is realized that when the design of the new Civil Engineering Building at East Lansing is completed there may be a more practical arrangement.

RED CEDAR RIVER

REYNOLS NUMBER

DRAINS (grating)

RESEARCH OUTLETS

FRICTION LOSS

PLASTIC FLOW

H. JUMP & WEIR

WATER HAMMER

PIPE CONSTANTS

RESEARCH OUTLETS

IMPULSE WHEEL

DRAIN

CALCULATORS

CALCULATORS & LECTURE ROOM

MODEL FLOW

STAND PIPE (SUB-BASEMENT)

PUMP #4

PUMP #3

PUMP #2

PUMP #1

EQUIPMENT ROOM

the PLAN VIEW of the PROPOSED HYDRALICS LABORATORY for M.S.C.

SCALE 1"=5'

CHAPTER V: CONCLUSION

In concluding the author wishes to convey several points. First, that with the design described in chapter number three, all the basic concepts of hydraulics and fluid mechanics may be illustrated. Also several of the more advanced theories may be clarified, such as Reynolds number, the current meter, and etc. Then too with the arrangement of the pipes and the space allowed advanced work may be done.

If one were to set out to design a laboratory for research with all equipment provided, he would in turn be doing advanced research himself. This is hardly practical since it is never known what is needed until the experiment is begun. About all that can be done is to supply the space, measuring devices, and source of supply. The rest must be constructed by the man himself.

So it is the author's belief that this design will be one of the most up to date laboratories in the nation and that this laboratory will be quite conducive to greater learning and knowledge which we are striving for.

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