[3] Objectives of Research work:

Main objectives of this research work are as follows:

- Design a simplified and easy operational mini hydraulic excavator attachment to minimize complexity concerned with available excavation attachment of machines/vehicles.
- Design of excavator backhoe attachment with smallest bucket capacity, which is very suitable for light duty construction work.
- To develop kinematic mathematical model to study motion of backhoe attachment mechanism.
- To improve working range by kipping less or same sizes of linkages of excavator attachment.
- To develop dynamic mathematical model to predict dynamic forces develop during the digging task and also it helpful to design controller to get controlled motion of backhoe attachment. It means it is applicable for autonomous application for excavation task.
- To predict the soil-tool interaction forces using the soil-tool models and to evaluate the digging forces using SAE standards.
- To carry out Finite Element Analysis and Structural optimize for minimum weight of excavator attachment (Bucket, Arm and Boom).
- To reduce the weight to cost ratio without compromise with strength.

Finally, to develop an optimized model of mini hydraulic backhoe attachment.

3.1 Justification for above mentioned research objectives:

Now days there are advanced robotic technologies are utilized in the excavation machines or vehicles but they are costlier and complex in nature.

All most all the excavator vehicles utilized by the earth moving excavation industries, infrastructure industries and contractors related to construction work are of heavy size and heavy duty in regular construction work. Some times that much heavy duty machines are not required carrying out the digging operation efficiently particularly for light duty construction work. In the construction work, the excavation machines/vehicles are utilized on hourly basis which is very costly for the small construction companies and ultimately the operating cost is high. In other words we can say that for normal/light duty construction work, it is not beneficial to use the heavy duty earth moving machines, so there is a new direction exists towards to develop new excavation machine attachment of smallest capacity, economical and simple in operation to fulfil the normal excavation work.

Big capacity excavation machines having larger dimensions of link mechanism and therefore we can get higher working range, but here there is a scope to improve the working range for excavation task by developing new model of backhoe attachment compare to available small
capacity models of different companies of earth excavation machine manufacturers. For that it is very necessary to understand the kinematics of backhoe attachment as well as it prerequisite of the development of the dynamic model. Also the kinematic model helpful to understand the motion of backhoe attachment mechanism and it provides relations between links and link dimensions.

The excavator backhoe working under the cyclic motion during the digging operation. The dynamics of the link mechanism and bucket are complex, there is uncertainty in the shape of the terrain and soil parameters, and the interaction forces between the excavator bucket and the soil environment are very large. So that it is necessary to identify the dynamic forces exerted during working. Again there is a scope for research work to carry out the dynamic model for the same and it might be validated through comparison of proposed dynamic model with available dynamic model developed by other researchers for the mini hydraulic backhoe excavator attachment. So it is necessary that all the parts of backhoe must be robust in design so that they can withstand against the unknown forces executed while digging.

Excepting few larger scale and well established infrastructure development industry, the others are come under the big circle of small and medium scale infrastructure industry. Still they are controlling excavator vehicle by manually, where a human operator plans and execute the bucket motion through the soil, with bucket loading and interaction force between the bucket and soil. During the digging operation, excavator operator cannot know about the terrain. So it is necessary to identify the soil parameters and soil behaviour and its effect on the bucket, because, the extensive amount of forces are executed during the digging operation. Sometimes these forces are adversely affected the mechanical components of the excavator backhoe and may be damaged during the digging process. Here still there is a scope to predict the soil-tool interaction forces using soil-tool models and it can be implemented for our application.

![Working Range of Mini Hydraulic Excavator](image)

**Fig. 3.1 Working Range of Mini Hydraulic Excavator**

Before actual manufacturing it is very important that to check the strength of the designed model of backhoes excavator attachment. So it is necessary to model the attachment using modelling
software and on which carry out the FEA to check the stresses developed in the various component of the attachment. To fulfil the function requirement, to improve performance and to reduce the initial cost of the attachment, it is important to perform weight optimization.

Based on the market survey, the technical details and physical dimensions gathered for available different models of the backhoe excavator attachment manufacturers and are compared. Finally based on reverse engineering, deciding the proposed dimensions of attachment and required working range of the proposed backhoe excavator model for research work. To fulfil the above requirement it is decide to build backhoe attachment, having least capacity to one and half of labour bowl at a time, with the working range (Ref. fig.3.1 and Table 3.1) and approximately bucket volume dimensions of 300 mm x 300 mm x 300 mm for light duty construction applications.

3.2 Utility of the Study:

- The Proposed research work will help the infrastructure development industries as well as the earth moving manufacturing industries by providing the new mini backhoe attachment which can be attach with the small capacity tractor unit (30 HP) and provide enough strength and stability for construction work.

- Excavator manufacturing industries can manufacture the robust and optimized back hoe and can reduce the overall weight of the machine as well as the cost, which can be used for unpredictable soil conditions and worst working environment.

- This research will help the construction industry, in which they can reduce their initial cost of the investment behind the excavator as well as the operating cost.

- The small and medium scale infrastructure development industries as well as the small contractors concerned with construction work can utilize the small capacity back hoe for their construction work with best economy and simple in operation at work site.

3.3 Limitations of the Study:

This research work is limited for the following aspects:

- This study is made only for the backhoe attachment portion of the excavator.

- The design of backhoe attachment will be carried out for excavation process for light duty construction work.

- The proposed backhoe is not design for mining application and for excavation of rocky terrain.

- Standard parts will be selected for hydraulic system.

- This study is limited for the bucket size of 300 mm x 300 mm x 300 mm.

- The dimensions of the arm and boom are restricted based on the digging depth decided minimum of 1.5 m only to carry out digging action for light duty construction work. The working range of the proposed excavator model is given in table 3.1.
Table 3.1 Proposed Working Range

<table>
<thead>
<tr>
<th>Working Range</th>
<th>Proposed Dimensions (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Digging Height (A)</td>
<td>2500</td>
</tr>
<tr>
<td>Maximum Dumping Height (B)</td>
<td>1650</td>
</tr>
<tr>
<td>Maximum Digging Depth (C)</td>
<td>1500</td>
</tr>
<tr>
<td>Maximum Vertical Wall Digging Depth (D)</td>
<td>1500</td>
</tr>
<tr>
<td>Maximum Digging Reach (E)</td>
<td>2650</td>
</tr>
</tbody>
</table>