[1] Introduction:

Earth moving excavation represents a huge potential and a favourable approach for many earthmoving operations including construction, mining, agricultural, forestry, military applications and especially for cleaning up hazardous areas, Nareshkumar N. Oza (2006).

Rapidly growing rate of industry of earth moving machines is assured through the high performance construction machineries with complex mechanism and automation of construction activity, Mehta Gaurav K (2008). An excavator is an engineering vehicle consisting of a backhoe with cabin for the operator and engine is used for power generation. Hydraulic system is used for operation of the machine while digging or moving the material.

Excavators are used primarily to excavate below the natural surface of the ground on which the machine rests and load it into trucks or tractor pulled wagons or onto convey or belts. They are capable of excavating all classes of earth, except solid rock, without prior loosening. They are adapted to excavating trenches, pits for the basement, and general grading work, which require precious control of depths. Earth moving excavators also called diggers. There are many variations in hydraulic excavators. They may be either crawler or rubber-tire-carrier-mounted, in which the crawler mounted excavators have very low travelling speeds, but the wide treads give low soil pressure, which permit them to operate on soft ground. Rubber-tire mounted excavators, which have higher travelling speeds then the crawler mounted units, are useful for small jobs where considerable travelling is necessary and where the road surfaces and ground are firm.

![Different parts of Hydraulic Excavator hoe](image)

**Fig. 1.1 Different parts of Hydraulic Excavator hoe**

There are many different operating attachments available. With the options in types, attachments, and sizes of machines, there are differences in appropriate applications and therefore variations in economical advantages. The hydraulic excavator hoe is shown in following Fig. 1.1.
The main components of the hydraulic excavator back hoe are as follows:

- Boom
- Arm, and
- Bucket

Excavators are used in many roles as follows:

- Digging of trenches, holes, foundations etc.
- Demolition
- General grading/landscaping
- Heavy lift, e.g. lifting and placing of pipes
- River dredging etc.

As per the varying size of the machine they are called as "mini excavators" or "compact excavators". Often the bucket can be replaced with other tools like a breaker or a grapple.

Hydraulic excavators are classified by the digging motion of the hydraulically controlled boom and stick to which the bucket is attached (see Fig. 1.2).

![Fig. 1.2 Digging motion of Hydraulic Excavator](image)

A downward arc unit is classified as a "hoe." It develops excavation breakout force by pulling the bucket toward the machine and curling the bucket inward. Hoes are used primarily to excavate below the natural surface of the ground on which the machine rests. A hoe is sometimes referred to by other names, such as backhoe or back shovels, Peurifoy Robert L., Schexnayder J. Clifford (2006). Penetration force into the material being excavated is achieved by the stick cylinder and the bucket cylinder. Maximum crowd force is developed when the stick cylinder operates perpendicular to the stick.
The ability to break material loose is best at the bottom of the arc because of the geometry of the boom, stick, and bucket and the fact that at that point, the hydraulic cylinders exert the maximum force drawing the stick in and curling the bucket.

In the selection of a hoe, the following factors must be considered:

- Maximum excavation depth required.
- Maximum working radius required for digging and dumping.
- Maximum dumping height required.

1.1 Motivation towards the Research:

Now a day, heavy duty work has taken a large portion of earthmoving industry. In our real life, we are looking the various areas such as construction work, mining excavation and forestry, in which the earth moving excavator continuously excavating the soil from different terrain and fills a bucket with material and this loaded bucket is dumped into the waiting truck or conveyer belt.

The earth moving industry utilizes various types of earth moving machinery with different attachments to carry out the fastest work within time limit. Also they are using advanced autonomous excavation machineries to overcome the various problems regarding excavation process and their control but these excavation machineries are very expensive and not affordable for small and medium size industries.

A detailed review on the Indian market for backhoe excavator was briefly covered in Off-Highway Research’s Multi-Client Study on India in October 2007, which will motivate to carry out research work in the same era, Off-Highway Research’s Multi-Client Study (2007). As per Off-Highway Research’s Multi-Client Study, the backhoe excavator market has been growing continuously for the last six years at a very impressive rate. With rapid urbanisation, GDP growth at over nine per cent and a government focus on developing the country’s infrastructure, the forecast for backhoe excavator demand is very positive indeed, and the market is expected to reach a level of 52,000 units by 2012. As a result, many new manufacturers, both domestic and international, are looking at entering the lucrative backhoe excavator market.

An analysis of the origins of India’s GDP shows that services and industry sectors are the main drivers of growth, whilst the importance of agriculture is decreasing year on year. The government focus on infrastructure development.

Growth in the Indian construction sector, including roads, power, housing and other infrastructure projects, has more than matched the expansion of the wider economy. The sector, which is the second largest employer after agriculture, has a workforce of 33 million and saw growth of 12.1 per cent last year. Large-scale civil engineering work to improve India’s infrastructure as, well as a booming residential and non-residential construction sector, have been the main drivers of this growth. The total investment in the sector amounted to $60 billion during 2006 and in the 11th Five Year Plan (2007-2012), with a staggering investment of $494 billion being allocated to infrastructure development alone. The construction industry’s value is
The backhoe is by far the most popular construction machine in India, accounting for around 45 per cent of the mobile construction machinery market. It is also the fastest growing market across the whole Indian construction equipment industry. Sales of backhoe loaders in India reached almost 22,000 units in 2007, a growth of over 58 per cent compared to 2006. In the last ten years, the backhoe loader market in India has grown more than tenfold from 2,172 units in 1998 to 21,769 units in 2007. JCB launched the first backhoe loader into India in the early 1980s through its then joint venture with Escorts. It continues to be the market leader and has a dominant presence with approximately 73 per cent of all sales. Other manufacturers of backhoe loaders in India are L&T-Case, Telcon, Terex-Vectra, Caterpillar, and more recently Action Construction Equipment (ACE) and BEML. All the backhoe loaders sold in India are manufactured in India (there have been no imports for the past three years) and there is only a small number of export sales to neighbouring countries.

The methodology of operating the machine by operator is very crucial job, otherwise it effect on the performance of operation as well as the failure of mechanical element of the excavator.

JCB successfully marketed its most popular backhoe in India – the 3D model – for over 15 years without any change in technology and still retained market leadership, mainly on account of the strength of its distribution network and backing by equipment financiers. With other manufacturers also not upgrading the technology used on their machines, all the backhoe loaders sold in India until as recently as 2003 had 15 year old technology.

The scenario started changing in 2002 when L&T Case introduced its 851 model and Telcon introduced its improved JD315 V (John Deere) model. In 2003 Caterpillar introduced its 424 Series I backhoe loader, with improved aesthetics, visibility and ergonomics, as well as upgraded structural components including a ‘banana’ boom, Z-bar linkage, oil cooled disc brakes, maintenance free axles and load sensing hydraulics with a variable displacement hydraulic pump. At the same time, Terex Vectra also introduced Fermec’s latest model, the TX760, and started manufacturing the machine at its Greater Noida plant in 2004.

These technological changes by its rivals in India forced JCB to respond. In 2004 it introduced its improved 3DX model and the company has since added the 3DX Super and 4DX. This trend towards upgrading technology has continued. In 2006, L&T Case launched its indigenously developed 770 model and Caterpillar introduced its improved 424B model, which has a much larger cabin and improved structural components. JCB is also working on new models for both the domestic and export markets, which might include some important new features that should secure its position in the industry. The following table 1.1 shows the comparison of production of backhoe excavators by manufacturers, during the period 2003 to 2007. This comparison shows that, tremendous growth of manufacturing of the backhoe excavator Off-Highway Research’s Multi-Client Study (2007).
Table 1.1 India: Production of Backhoe excavator by Manufacturer, 2003-2007 (Units)

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>JCB</td>
<td>3,480</td>
<td>5,200</td>
<td>7,400</td>
<td>10,400</td>
<td>16,066</td>
</tr>
<tr>
<td>Telcon-JD</td>
<td>400</td>
<td>462</td>
<td>850</td>
<td>1,425</td>
<td>2,000</td>
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<tr>
<td>L&amp;T-Case</td>
<td>480</td>
<td>525</td>
<td>695</td>
<td>1,183</td>
<td>1,950</td>
</tr>
<tr>
<td>TEREX Vectra</td>
<td>-</td>
<td>87</td>
<td>310</td>
<td>775</td>
<td>1,285</td>
</tr>
<tr>
<td>Caterpillar</td>
<td>47</td>
<td>245</td>
<td>235</td>
<td>215</td>
<td>700</td>
</tr>
<tr>
<td>Others</td>
<td>-</td>
<td>8</td>
<td>10</td>
<td>45</td>
<td>225</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4,407</strong></td>
<td><strong>6,527</strong></td>
<td><strong>8,735</strong></td>
<td><strong>14,043</strong></td>
<td><strong>22,226</strong></td>
</tr>
</tbody>
</table>

Herein the greatest opportunity for development of optimized design with most economical consideration particularly for construction work and which is beneficial for small as well as medium scale earthmoving and construction industries.