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Analytical Method To Calculate Tooth Pin Failure Of Bucket Tooth Of Excavator In Shearing And Bending.

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ABSTRACT

A better tool design in the excavation process has been always a challenging task for the engineers. A poorly designed tool always results in poor excavation of the ground, higher wear of the tool, wastage of the time, and power. But proper understanding of the soil mechanics in context of the soil cutting process may help in a better tool design. Moreover it requires the resistive forces offered by the ground on the bucket. The excavation force necessary to cut the soil by the excavator bucket tooth has been analyzed in this to improve the design of the bucket teeth. The method used for calculating the excavation force is based on 2D analytical soil tool interaction models. The existing excavator bucket tooth assembly was analyzed for the operational loading conditions for its failure during working at various locations and as per soil structures.

Keywords— Excavation, soil mechanics, bucket tooth, soil failure, etc.

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I. INTRODUCTION

An excavator is a piece of heavy equipment that is commonly used in construction work, mining work and work that requires lifting that can be too heavy for humans. An excavator is a vehicle that is engineered and consists of things that can be used such as a backhoe and also has a cab that tends to be mounted to the back pivot near the undercarriage. It also has tracks and wheels that it is running on paper.

Excavators can come is a huge variety of sizes and shapes. One can purchase or rents that are called mini excavators as well ones that are referred to as compact excavators. They can very little and have a big pretty bucket size to still get the work done, that you need. Sometime one can get models that the bucket can be replaced with other objects. Most of the time, excavators are used with loaders and bulldozers to get the most of the job done. Many of the excavators have tracks, but one gets them with wheel preferably.

Fig.1 A typical tooth failure

As the use of excavator in day to day life is increasing for many purposes but the applicable site is not inspected properly due urgency of work by the owner or the contractor due to which improper handling of it leads to damage of the ground engaging tool i.e. bucket teeth.

II. Problem Definition

In this work, my main emphasis on the bucket tooth which comes first contact with soil for its contact deformation as well as the stress generation in it for doing various types of operations at various sites in India.
As shown in above figure, the failure is of pin failure in shear, bending as well as the tooth point also in bending. So, to find the solution, this analysis work is being done.

III. Working Of The Excavator

3.1 Excavator Operations

As in the market, there are many companies which are doing business in the earth moving equipments. Depending upon the type of the application, the different types of equipments are used. The excavator is also one of them which mostly used for excavation in mines, hills, etc. etc. mainly excavator is nothing but the type of machine which has working boom, arm and bucket for excavation, loading etc. which are interconnected and well controlled by the hydraulic power. The whole engine and body is mounted on the base structure which is very much rigid, strong with maximum load bearing capacity. The boom also mounted on the support structure which well connected and controlled by operator with joystick from the operator cabin.

The boom of the excavator consists of two hydraulic cylinders which have to bear maximum load i.e. working load. As the boom is the integral part of the excavator, it has to control the stick movements also. The stick is mounted on boom with connecting cylinder to guide from top for its respective movements.

3.2 Possible Failure

After doing such operation, there is possibility of breaking of pin in tooth adapter assembly as well as the bending of tooth point. So to calculate the probable failure, the wedge shaped tooth has considered as shown in figure for this work.

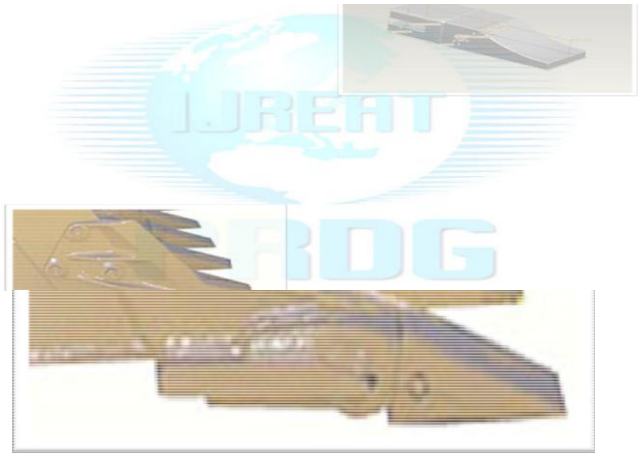

Fig.2 Wedge Shaped Tooth

IV. Analytical Calculations

4.1 CAD Model

4.2 Material Properties

Tooth and Adapter: AISI 1040

Modulus of Elasticity	=	205 GPa
Poisson's Ratio	=	0.29
Ultimate Tensile Strength	=	670 MPa
Yield Tensile Strength	=	435 Mpa

Pin : AISI 4130

Modulus of Elasticity	=	200 GPa
Poisson's Ratio	=	0.29
Ultimate Tensile Strength	=	595 Mpa
Yield Tensile Strength	=	370 MPa

4.3 Calculations

Maximum top reach distance	=	6.37 m
Time required to reach at ground	=	3.5 sec
Weight of Boom	=	3200 kg
Weight of Stick	=	1800 kg
Weight of Bucket	=	930 kg
So, Total weight	=	5930 kg

Now,

Work Done = Change in Total Energy (Impact Force) X (Distance) = K. E. + P. E.

Kinetic Energy = Final K.E.-Initial K.E.
Potential Energy= Final P.E.-Initial P.E.

As we know,

$$K.E. = \frac{1}{2}mv^2$$

$$P.E. = mgh$$

And,

Now, Velocity with which the whole assembly reaches to ground is given by,

= 1.82 m/s

Calculating Initial Energies;

$(P.E.)_1$	=	mgh
	=	370563.9 J
$(K.E.)_1$	=	0 J

Also, Final Energies

$(P.E.)_2$	=	0 J

$(K.E.)_2$ = ½ mv^2
= 9821.27

Also,

Work Done = - F x d
-360742.63 = - F x 1
-F = 360742.63 N
But, No. of teeth = 5 Nos.
So, Force on each tooth will be,

F_T = 72.15 KN

4.4 Stresses Generated in Pin due to impact Force:

1) Pin may Fail in shear:

Force = 72.15 KN

Area = $\pi/4\ D^2$
= 706.86 mm^2
Force / 2 Area i.e. double shear
σ_s = **51.04 Mpa**

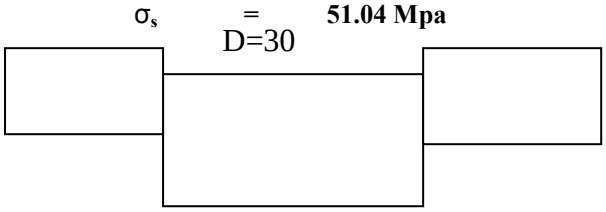

Fig.4.1 Double shear in pin

Pin may fail in Bending:

Maximum bending will be at center of the pin,

So,

$(BM)_{max} = F/2\ (50+25/3) – F/2\ (25)$

= 1202500 N-mm

Section Modulus,

= 2650.72 mm^3

σ_B = 453.65 Mpa

V. CONCLUSION

From the above analytical calculation it has been found that the maximum stresses are generating at the tooth point due to the regular and maximum contact with the soil. These stresses cannot be avoided but can be properly regulated with proper application of bucket for the excavation for various soil structures.

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