

KOBELCO Large-sized SK3500D Demolition Machine

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KOBELCO large-size SK3500D demolition machines, with a working height of 65.03m, are the largest in the world. These machines were designed to dismantle tall, strong buildings. Kobelco has adopted a new machine structure design which incorporates detachable built-in hydraulic pins. Such pins improve the disassembly and transportation of these large machines. This paper outlines KOBELCO SK3500D and the technologies used in its design.

Introduction

Recent urban redevelopment and renewal of obsolete plants, such as iron foundries and power plants, is encountering structures, to be demolished, which are becoming taller and stronger, making their demolition work complex and difficult. To overcome such difficulty, there is a need for large demolition machines and large attachments mounted to the machines. In response to such demands, KOBELCO CONSTRUCTION MACHINERY CO., LTD. developed a demolition machine, SK3500D, which has the tallest working height in the world.

There are two methods to demolish tall buildings and plants. One is to install a machine on a roof and demolish the structure from the roof downward. The other is a demolishing method from the ground, involving ultra-long attachments extended from the ground. The latter provides advantages in demolishing plants, such as iron foundries and power plants, having insufficient floor strength to install demolition machines on the roofs. Demolition work requires not only work efficiencies, but various other factors, such as short demolition periods, including assembly and disassembly of the machines, and safety for increasing high-place works. The present article introduces the outline of a large-sized demolition machine, SK3500D (Photo 1).

1. The outline of the large-sized demolition machine, SK3500D

1.1 Main specifications

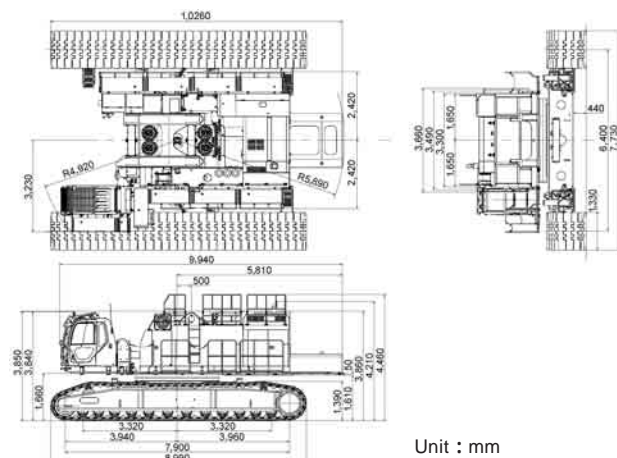
Table 1 summarizes the main specifications and Figure 1 shows the general dimensions of SK3500D.



Photo 1 The appearance of an SK3500D

Table 1 Main specifications of SK3500D

Operating mass	t	327.6
Rated output	kW/min ⁻¹	338/1,800
Maximum working height	m	65.03
Maximum working radius	m	22.0
Swing speed	min ⁻¹	1.8
Travel speed	km/h	1.1/0.7



Unit : mm

Fig. 1 General dimensions

1.2 Outline of SK3500D

1) Outline of the SK3500D main frame

An SK3500D has a maximum mass of 327t, including all the attachments, and reaches a maximum height of 65m, when installed with a nibbler with 2.9t mass. The lower structure of the SK3500D is designed based on a crawler crane having 200t lifting capacity and satisfies stability and disassembled-state transportability, both of which are required for large demolition machines. The total crawler width of 7,730mm, at work, assures stability for all pivoting angles of the upper body. Usually, cabs of a demolition machines fit within the total width of the upper body, however, the cab of an SK3500D extends beyond the width of the upper body. This is because of the large boom fit-width, to secure enough strength to support attachments, which can be as tall as 65m at the maximum. The cab is designed to be a swing type (**Figure 2**), so that it is folded to make the upper body fit within the width of the regulation limit during transportation.

2) Improvement in workability

The present machine can change its work height by combinations of attachments and can have nibblers of different sizes. For example, at the work height of 65m, the nibbler is limited to one with opening width of 1,600mm, maximum force of 1,341kN with mass of 2.9t. On the other hand, at the work height of 41m, the nibbler can be as large as mass of 12t, opening width of 1,600mm and maximum force of 2,716kN, which is more than two times the capacity at 65m. **Table 2** summarizes the specifications of nibblers which can be used at representative heights of 65m, 53m, 50m, 45m and 41m. The combination of working heights and nibblers allows demolition of a wide variety of demolition objects.

The cab has a tilt mechanism, which allows upward tilting of 30 degree at maximum for improved

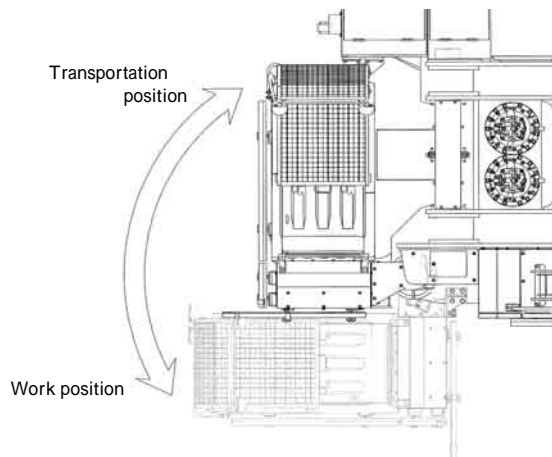


Fig. 2 General dimensions of swing cab

Table 2 Combination of nibbler

Working height	41m	45m	50m	53m	65m
Nibbler type	KR1600TPR	KR1500PR	KR1200PR - 2	KR1100PR - 2	KR1000LPR - 2
Mass (t)	12.0	6.7	4.75	4.0	2.87
Maximum cutting force (kN)	2,716	2,195	2,029	1,764	1,314
Maximum opening width (mm)	1,600	1,500	1,200	1,100	1,000

visibility.

3) Shortening of assembly/disassembly time

The machine is transportable on trailers in up to 17 segments, each complying with regulations including the road transport law, as shown in **Figure 3**. The assembly time at a work site is shortened by various apparatuses.

The machine has a remote-controllable trans-lifter, which is actuated by the four hydraulic cylinders of the crawler crane and hydraulically-actuated pins, both of which allow safe disassembly of the crawler frame on both sides of the lower body. An unique, built-in, hydraulic pin, for the boom connection, was developed for the assembly and disassembly of the attachments, which significantly shortens the work time compared to the conventional pins inserted from outside.

The counterbalance weight, having a mass of 100ton, is separated into seven segments, so that appropriate weights can be chosen according to working heights.

2. Technologies used in SK3500D

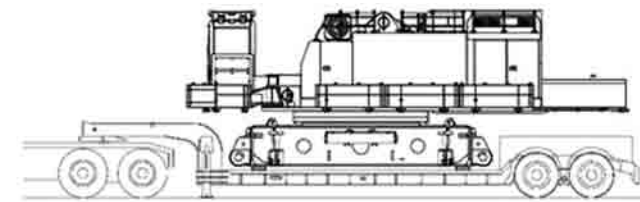
2.1 Development of a high reach demolition attachment structure.

Various structural analyses were performed in the development of SK3500D to assure self-standing support of various attachments, which can be as long as 65m at maximum. Service life and work frequency were also taken into consideration in the analyses. In order to verify the design, simulations were performed based on the actual data obtained from conventional machines. Machine tests were carried out under the same conditions as the simulations until quantitative data, matching the analysis results, were obtained.

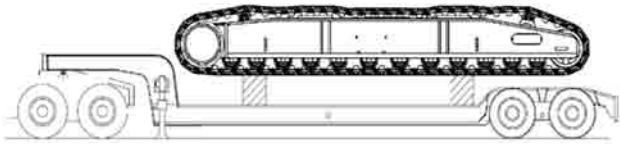
2.2 Built-in hydraulic pins

1) The purpose and effect of built-in hydraulic pins

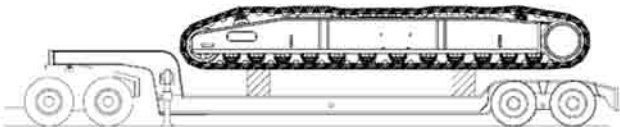
An SK3500D is equipped with built-in hydraulic pins for connecting the upper body to the base of the main frame and, also, for connecting each boom part (20



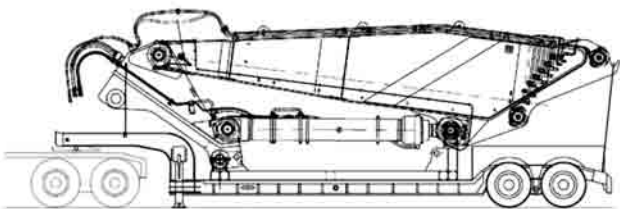
#1 Upper frame assembly ()



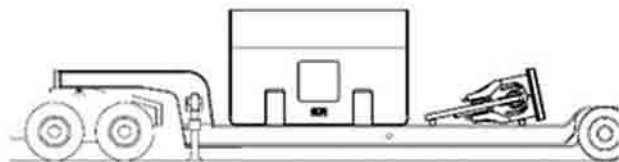
#2 RH crawler frame



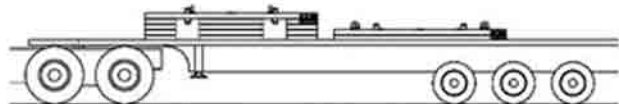
#3 LH crawler frame



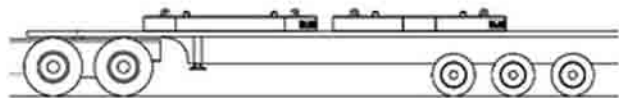
#4 N1 boom and adapter ()



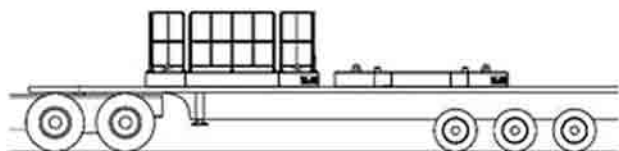
#5 Counter weight



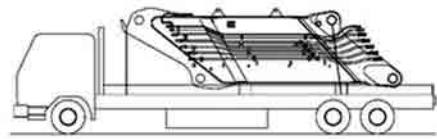
#6 Counter weight



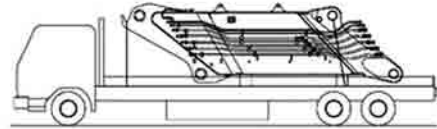
#7 Counter weight



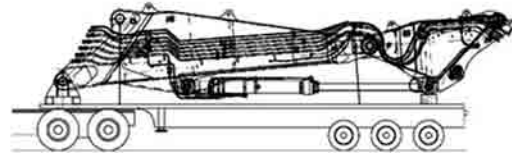
#8 Counter weight



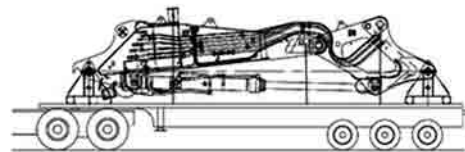
#9 N2 boom



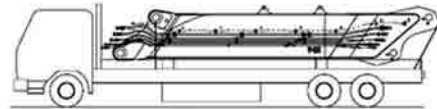
#10 N3 boom



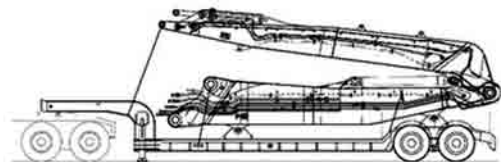
#11 N4 boom + N5 boom ()



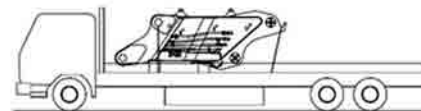
#12 N6 boom + N7 boom



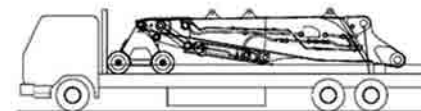
#13 N8A boom



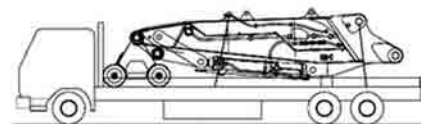
#14 N9A boom ()



#15 N8B boom



#16 N9B boom



#17 N9C boom

Fig. 3 Machinery parts for transportation

positions for maximum four-fold, 65m attachment). The application of hydraulic pins shortens the assembly/disassembly time significantly, while improving the work efficiency for pin connections, and safety. **Photo 2** and **Photo 3** show an actual pin in a shortened position and in an expanded position, respectively.

2) The structure of the built-in hydraulic pin

Figure 4 and **Figure 5** are cross sectional diagrams of



Photo 2 Shortened position of pin



Photo 3 Expanded position of pin

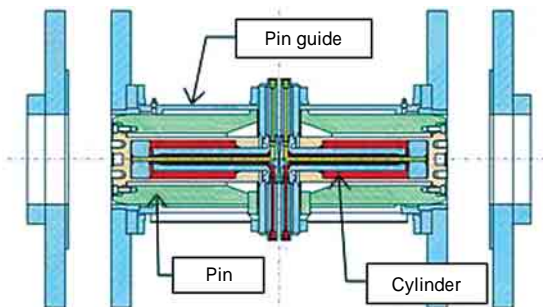


Fig. 4 Cross section of shortened pin

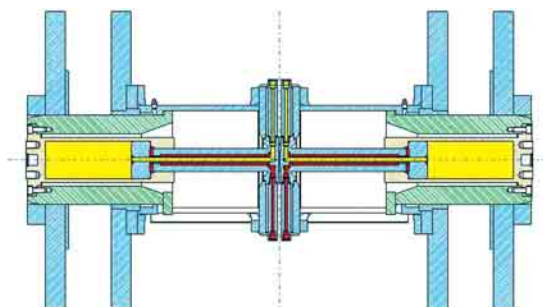


Fig. 5 Cross section of expanded pin

the built-in hydraulic pin in shortened and extended positions respectively. The built-in hydraulic pin is designed to fit in the widths of structures such as the boom. The pin has a cavity inside and, when shortened, the cavity contains the hydraulic cylinder inside, so that the total width is made small. The cylinder has dual pipe rods, which are extended by oil supplied from the rod side. The pin moves along a pin guide and, when extended, the rods push against each other. When shortened, reactive force is exerted on the pins.

The cylinder is made independent from other parts, such as pins, for ease of maintenance.

2.3 Safety features

A fall alert apparatus was installed to ensure work safety. The apparatus monitors the posture of the machine, using angle sensors installed at the pin portions of the attachments. The apparatus calculates the working radius, based on the arm tip position of the demolition machine, and alerts the operator of potential fall, when the radius becomes more than a predetermined value.

The apparatus is important, not only for large demolition machines, but for all the demolition machines with high reach demolition attachments. The machine has several features for hazard prevention, including a low gravity point and low ground pressure, characteristics of the lower structure of a crawler crane, and the safety apparatus.

In addition, two cameras are installed for monitoring. One is installed at the tip of the attachment, allowing monitoring of demolition work at that point. The other monitors the rear view of the machine. Other safety features include a main-body tilt alert system, which gives a "buzzing" alert when the main body tilts beyond a limit angle, and fall-prevention valves, installed on cylinders for boom, jib and arm, which prevent sudden drops in the event of hydraulic pipe failures.

3. Development of attachment nibblers

KOBELCO CONSTRUCTION MACHINERY CO., LTD. has a history not only in the design of demolition machines, but also in development of attachment nibblers. After introducing technologies from HYMAC, Inc in UK, we have developed our own menu items for large machines. Two nibblers, both having 12t demolishing capacity at work height 41m, the most common height, were developed for SK3500D; KR1600TPR for steel reinforced concrete and KS1300 TPR for structural steel work. Recently, demolition structures are becoming stronger and



Photo 4 KR1600TPR in operation



Photo 5 SK3500D in operation

demolition machines are required with both a large opening width and high demolition power. Our dual-cylinder structure enables the wide opening and a small variation of demolition power for all the work angles, making demolition work more efficient. **Photo 4** shows a KR1600TPR in operation.

Conclusions

Since the delivery in Oct., 2005, SK3500D has been used in demolition of high rise buildings and plants

all over Japan (**Photo 5**). The machine entered the Guinness Book of Records in Oct., 2005, as the machine having the tallest working height in the world.

Environment related needs, not only in the demolition work, are more and more diversifying and specific requirements are increasing. We will strive to produce unique products in response to those demands.

Finally we would like to express our sincere gratitude to Watanabe Kaitai Kogyo for their cooperation in the development of the machine.