Boring Operation at 5,400 m a.s.l. in Yala Glacier, Langtang Himal, Nepal: A Technical Report

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1. Introduction

Many difficulties naturally affect boring machine performance and generator capacity, both as to logistics and actual boring operations when undertaking glacier boring at high altitudes such as in the Himalaya. Since the early 1970s, glacier boring has been attempted in the Swiss Alps using an electromechanical machine that was developed and improved on polar ice sheets (Vallon, 1976; Oeschger et al., 1977). In 1981, the first attempt at glacier boring to the bed for full depth core sampling was performed in the Yala Glacier, Langtang Himal, Nepal, using an improved Himalayan type boring machine. After reaching the bed at a depth of 30 meters in the ablation area, 60 m complete sampling was performed in the accumulation area.

Technical reports on these boring operations carried out during 1981 and 1982 are presented here.

2. Mechanical description of Himalayan type boring machine

The boring machine system used in the project was an improved version (Himalayan type) of the prototype system for surface and medium depth boring on polar firn and ice which was originally designed by Prof. Y. Suzuki (Suzuki and Shiraishi, 1982) and manufactured by Chikyukogaku Kenkyusho Inc. Ltd. This lightweight system can be readily broken down into 12 components for easy transport. The total net weight of the system is about 300 kg.

The system (1982 type) is schematically illustrated in Fig. 1, and the dimensions of boring system are indicated in Table 1. The boring system consists of a driving system and a coring system (barrel part) suspended on a 130 m length of armoured cable. The driving system is composed of a spring, connected to the cable, a motor and a reducer, and an anti-torque mechanism consisting of four guide fins with side cutters.

The coring system consists of a 1,053-mm-length core barrel covered by a 2,125-mm-length fixed jacket; at the end of the barrel, four bits and vertical paws for core entrapment are equipped. The drive motor (350 W at 24,000 rpm) has an input of 1ϕ, 200 V, 3 A; the 400 W winch motor has a rated output of 1ϕ, 50/60 Hz, 100 V, 15 A (Suzuki SE 1500), and weight about 40 kg.

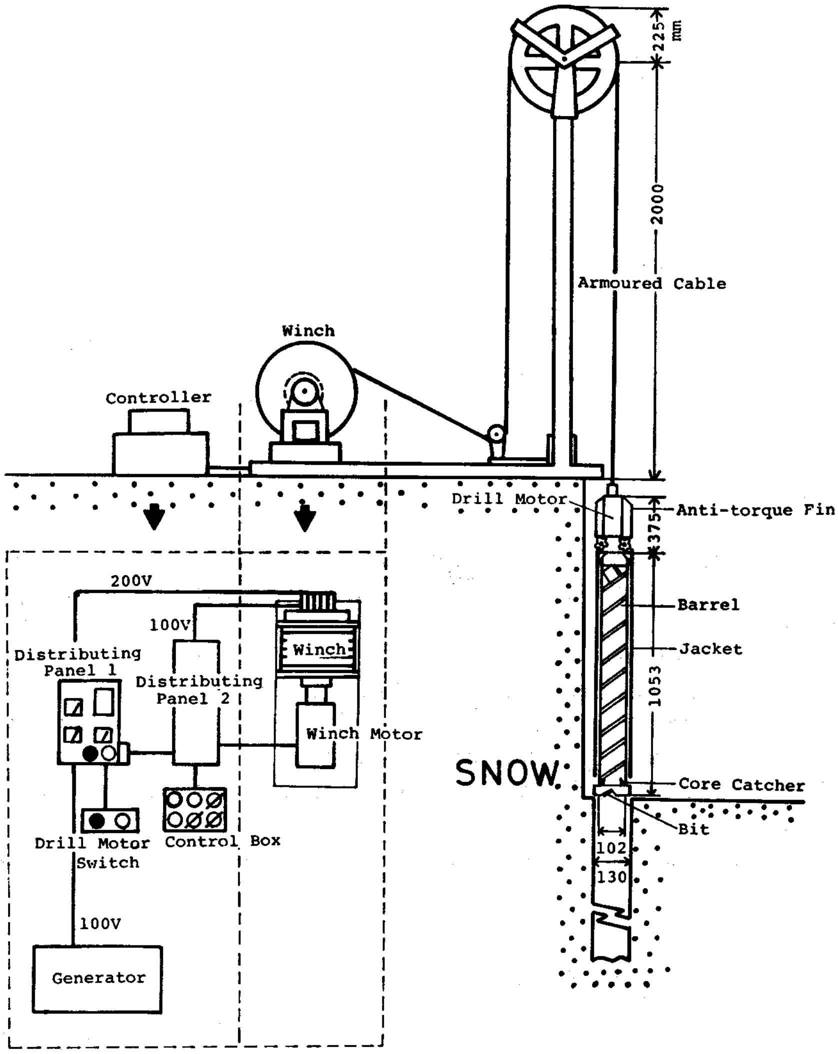

Fig. 1. The system of glacier boring

3. Boring operations

3.1. 1981 operation

Boring was begun on November 21th and finished on the 27th of the same month in 1981. During this period, the weather was usually fine, and the air temperature varied from −15°C to −2°C. Adjustment of the carburetor, air filter and gear oil, to comply with the low atmospheric pressure and temperature, was required. Two members of the team operated the boring machine for total of 25.3 hours for the seven days and bored 30.9 m down to the glacier bed. The total fuel consumption was approximately 16 liters.

3.2. 1982 operation

During the autumn of 1982, the main base for this project was set up in the accumulation

Table 1 Specifications of boring drill

		Himalayan type-1981 (ILTS 130A)	Himalayan type-1982 (ILTS 130D)
Basic diameters	Std. core dia.	102.0 mm	102.0 mm
	Barrel (outer dia.)	127.0	127.0
	Jacket (outer dia.)	132.0	132.0
	Std. hole dia.	133.0	133.0
Barrel	Length (std.)	1.0 m	1.053 m
	Number of vert. paws	4	4
	Number of bits	4	4
	Std. rpm	100	100
	Number of fins	2	2
Drive unit	Input (V)×(A)	200×4.5	200×3
	Output (W)/at (rpm)	450/10000	350/2400
	Weight (kg)	19.0	9.0
	Length (m)	0.52	0.418
Overall dimension (std.)	Weight (kg)	30.0	20.8
	Length (m)	1.5	1.428
Winch	Type	MA-400M (Toyokoken Co., Ltd.)	(Nakamoto Mfg. Co., Ltd.)
	Output	400 W, 100 V	400 W, 220 V
	Speed	24 m (50 Hz), 29 m (60 Hz)/min	20 m/min
	Cable	normal 4 mm 110 m	armoured 6 mm 130 m
	Weight	30 kg	60 kg

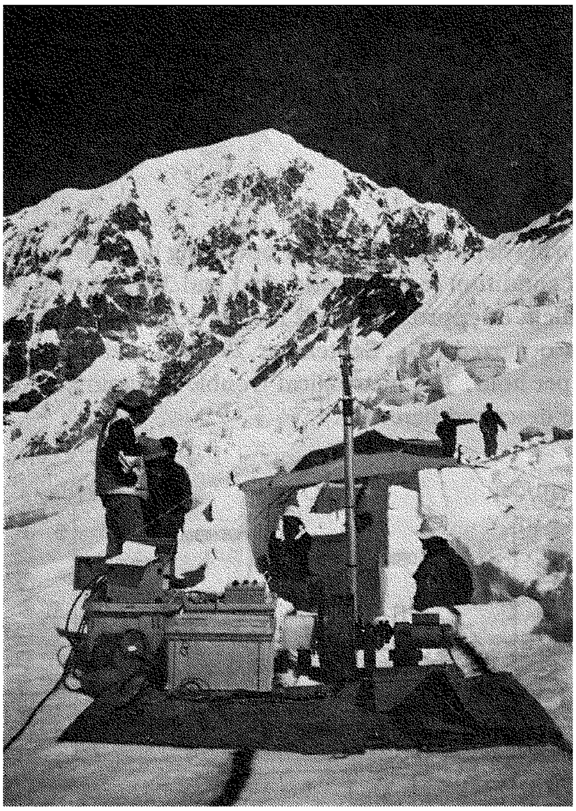

Fig. 2. The 1982 boring site at an altitude of 5,400 m of Yala Glacier
The behind peak is Langtang Lirung (7,234 m)

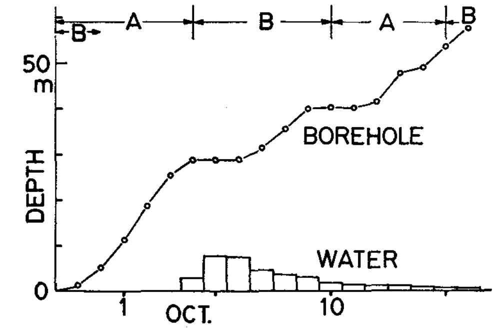

Fig. 3. The operational progress of core boring
A, B: Term of the operation team

area at an altitude of 5,400 m. The boring site is shown in Fig. 2. While this high altitude puts a limit on a long-term stay, a well-acclimated person can stay more than one month without oxygen aid. A secure access route to the boring site had been found during the 1981 pilot expedition. The 1982 operation started immediately after the 1982 monsoon season was over, with the hope of early completion before the arrival of severe winter cold. After ten days preparation for logistic setting and installation of the system, the boring operation was started at on September 29th with two teams of 3 each, rotating every 5 days. The maximum depth of 59 m was reached on October 16th.

The operational progress, depth attained in a day, and mechanical troubles encountered, were indicated in Fig. 3. At a depth of 27 meters, boring struck an abrupt spout of infiltrated melt water, considered as a phenomenon of the water table. Daily changes in the water volume were also shown in Fig. 3.

4. Mechanical problems

The daily rate of boring depth and generator operating hours were shown in Fig. 4. As seen in Fig. 4, under good condition (e.g., October 2nd and 3rd) up to 6–7 meters can be bored per day, or the equivalent of approximately 2 meters per hour. On the contrary, when some mechanical problems occurred (e.g., September 29–30th and October 7–14th), the boring depth fell to 1 meter per hour. The mechanical troubles encountered during operations and the remedies used are described herewith.

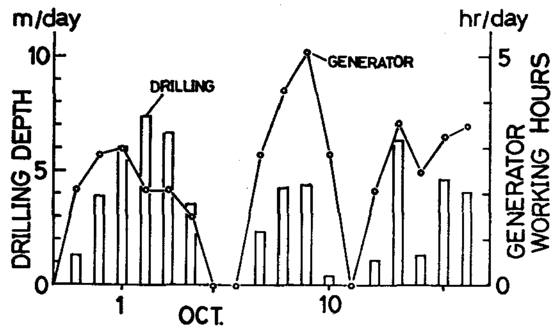

Fig. 4. The daily mechanical description

4.1. Trouble in anti-torque system

The upper 10 meters of the firn layer surrounding the boring site, as described in detail by Iida et al. (1984), consist mainly of temperate loose granular snow. Due to this firn layer condition, the anti-torque fins did not efficiently act as rotation stopper. To remedy this difficulty, the effective length of fins was increased by installing one of the two sets of fins upward, fixing the one edge to the armoured cable, and keeping the other in the original position. While the 1982 project driving system was too short (26 cm) for this kind of loose snow, the length of the 1981 type (37 cm) worked fairly effectively, judging from a test made afterward in situ. In such a temperate loose firn, the vertical paws for core entrapment were also not so effective. Thus, two plastic plates (15 mm $\times$ 50 mm) were attached to the paws to increase friction.

4.2. Troubles during the occurrence of spouting water

Various troubles occurred which resulted from the water in the bore hole. Under the above-mentioned conditions, the most severe was the submergence of the boring machine in the bore hole, with the result that the motor and the reducer were flooded. This led to decreased lubrication and eventual gear break down. The fundamental cause of this trouble is the lack of proper water proofing for the mechanism.

Under ordinary conditions, cutting slime is carried upward along spiral guides on the outside of the rotating barrel due to friction with the outer jacket. It then falls down inside the barrel through an opening when the slime reaches the upper end. Wet slime, however, forms a plate due to snow compaction and is choked at the upper end frequently overloading the drive motor and sometimes causing rotational lock. Also water freezing on various inside parts prevents smooth action and on the whole causes motor overload.

4.3. Generator troubles and performance at high altitudes

Since partial oxygen pressure at an altitude of 5,400 m a.s.l. is half that at sea level, the air/fuel mix must be adjusted. Increased air charge flowing into the combustion chamber resulted from removal of the air filter. While the generator can supply necessary power to the boring system by these means mentioned above, the decreased cooling effect due to evaporation of fuel leads to overheating. Good ventilation is the best and simplest remedy.

The generator power at the boring site altitude decreased about 70 % of that at an ordinary

Table 2 Boring problems and remedies

	Drilling system		Generator
1982			
(9/29)	Failure of anti-torque mechanism due to loose firn; upper 10 meters →* shifting one of two set fins upward		
(10/1)	Failure of vertical paws → attached a plastic honeycomb plate due to increase friction	(10/1)	Smoking spark plug → changed spark plug 5HS to 6HS
(10/2)	Blade slipping → changed blade angle (35°–30°)		
(10/4)	Boring machine flooded by spouting water → drying	(10/4)	Overheating → better ventilation
		(10/7)	Unstable power generated → removal of air cleaner
(10/8)	Freeze-up of driving motor → drying		
(10/9)	Reducer failure → dismantling and lubrication		
(10/13)	Reducer damage → changed boring head from 1981 to 1982 type		

*Arrows indicate remedy

altitude, resulting in constant overloading of the winch driving it at starting. Due to this condition, daily operating time had to be kept within 5 hours.

From the start to completion, boring took 43 hours over 18 days and 28.2 liter of fuel were consumed. The 2.05 meter/liter rate was more favorable than expected. The 1.5 working hour/liter rate was 1.5 times that at ordinary altitudes. Table 2 summarized the problems and trouble shooting measures used.

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