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Artikel: Chimney No. 1, Duvha Power Station (Rep. of South Africa)

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1. Chimney No. 1, Duvha Power Station (Rep. of South Africa)

Owner: Electricity Supply Commission (Escom)
Engineer: Ove Arup & Partners, Johannesburg
Contractor: Monahan & Frost (Pty) Limited
Work's Duration: 24 months
Service Date: 1979

Chimney No 1, at Duvha Power Station in the Eastern Transvaal, has a height of 300 m and ranks as the tallest structure in South Africa. It will handle the exhaust gases from the first three boilers of the power station, and, to this end, has three independent inner flues. With the first flue having been completed in March 1979, the chimney is the first major multi-flue power station chimney in South Africa.

All the basic design parameters for the chimney, including gas volume, maximum exhaust gas velocity, temperatures, etc, were provided by the client, Escom. The height of 300 m was required by the pollution control authorities and is comparable with heights subsequently demanded for similar chimneys nearby at Matla Power Station and Sasol II.

A preliminary investigation was undertaken by the designers to compare single- and multi-flue chimneys and alternative flue linings for this height of chimney.

A multi-flue chimney, which consists of an outer windshield and several independent inner flues, has important advantages over the single-flue design. Inspection and maintenance of one flue can take place without affecting the functioning of the remaining flues, thereby avoiding the serious consequences of having to shut down three boilers simultaneously for maintenance. The multi-flue configuration also facilitates the provision of protected access for inspection of the flues, maintenance of aircraft warning lights, handling of instrumentation and recording devices, and other service functions.

The increased cost of a multiflue chimney is significant compared with the cost of a single-flue structure, but small in relation to the total power station cost, and can be set off against shutdown costs during the service life.

Chimney configuration

Various multi-flue chimney configurations were considered by the design team with a view to minimising the total cost within the constraints of the functional requirements and specifications.

After considering the alternatives in detail, it was decided to adopt the simplest solution of a cylindrical windshield of nearly constant external diameter with three independent circular, brick-lined concrete flues founded on a pile cap and piles at ground level. This approach was thought to be the most economical and to offer the most rapid construction time.

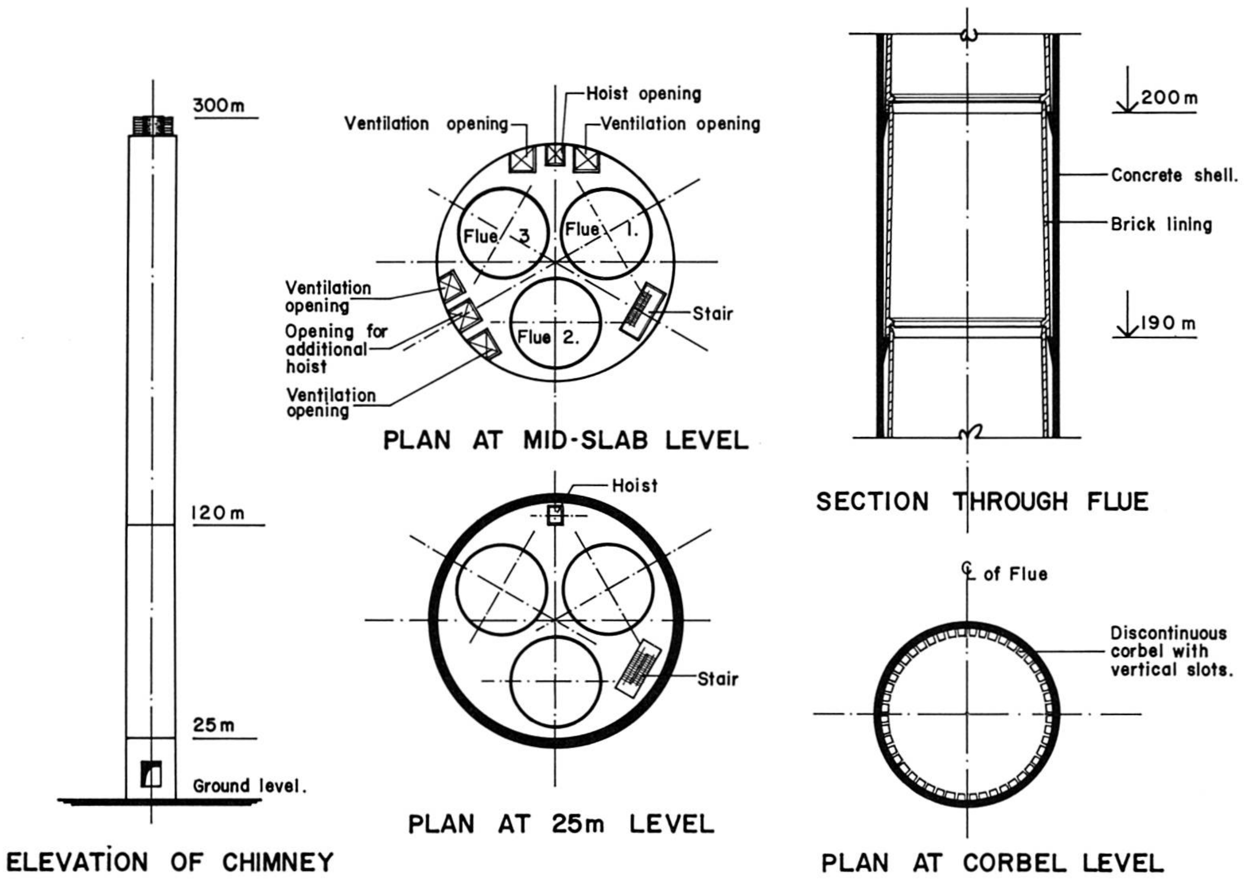


Fig. 1 Duvha Chimney Details

Among the alternatives considered were: brick flues supported by intermediate platforms onto the windshield at regular intervals: a tapered windshield and varying wall thicknesses to optimise cost; and stopping the windshield at a height of some 90 m below the top of the chimney, above which the concrete flues themselves would be the main structural member.

The configuration adopted had the advantage that all four circular members have uniform shuttering and a sliding form could be utilised to speed up construction and might reduce costs. From the tenders subsequently received, it appeared that a conventional hand-over-hand construction method was more economical than sliding in this case. This system enabled the brick lining to be constructed close behind the climbing shutter. Additional cost savings were then obtained by using the advantages of this system to taper slightly and change wall thicknesses at different heights.

The solution chosen is shown in the diagram accompanying this article.

The three ducts from the boilers enter the chimney symmetrically at 120 deg. around the circumference. The ducts are connected to the flues through openings in the wind-shield.

To reduce deflection of the slender flues, horizontal connections are made between the flues and the windshield by slabs at two levels, namely 290 m and 160 m above ground. The connections are designed to provide horizontal restraint while allowing free vertical movement and rotation by using rubber bearings with Teflon sliding surfaces.

The airspace between the flues and the windshield is provided with natural ventilation.

It is interesting to note that a sliding shutter form of construction has been adopted for the similar 275 m high chimney at nearby Matla Power Station, while the alternative, using intermediate platforms supporting the brickwork, was chosen by the contractor for the 250 m high chimney at Sasol II.

Flue linings

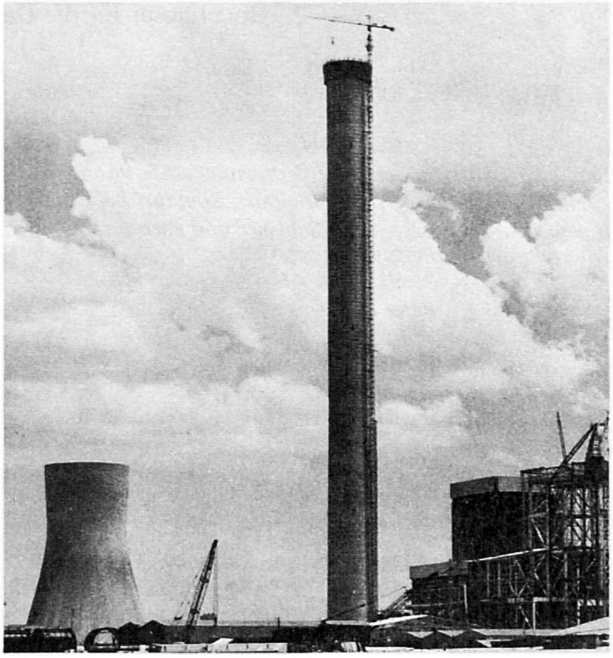
An important design decision was the selection of the flue linings. These have to withstand varying temperature conditions, chemical attack from the flue gases, and abrasion by particulate matter in the flue gases.

Several types of linings were considered, namely metallic liners; plastic liners; refractory, vitreous and brick liners; and concrete liners with acid resisting concrete or gunites or internal surfaces with sufficient resistance to corrosion.

The alternatives were compared with regard to performance and cost, drawing on an extensive study of experience both in South Africa and overseas.

In the light of the above considerations, it was decided to use a dense, highly vitrified, hard brick conforming to SABS 227-1970 and ASTM C279-54 (1970). Bricks of this quality are required to meet certain requirements with regard to water absorption and acid attack and are referred to as semi-acid bricks.
An acid resisting mortar was chosen, the most suitable being one in which potassium silicate is used as a base.

The inside surface of both the brickwork and the flue concrete is painted with a surface densifier in the form of a silica depositing paint to reduce surface permeability and so reduce corrosion by limiting the penetration of acid and moisture.



Generally the flue lining is a single 110 mm thick brick skin although in certain areas, for example at the flue inlet, a double brick skin of 230 mm thickness is used.

The internal brick lining is supported on corbels at 10 m intervals and each segment is slightly tapered to a top diameter of 6880 mm. The corbels are discontinuous around their circumference having vertical slots through the corbel. An air gap of 150 mm average size is maintained between the outer surface of the brickwork and the flue concrete and is ventilated through the slots in the corbels.

Internal access and service facilities

The interspaces between the flues and the windshield are accessible during operation of the flues. Maintenance and inspection facilities are provided from within this space from a series of walk-ways and platforms. Vertical access is provided by a stairway and a passenger/materials rack-and-pinion hoist.

Instrumentation

An interesting aspect of the structure is that it is designed to accommodate instrumentation to measure both the internal service conditions in the flues and the dynamic wind pressures applied to the windshield.

The proposed structural instrumentation is intended principally to determine the instantaneous wind pressure distributions over the windshield. This will involve the simultaneous recording of data from many pressure transducers placed around the circumference of the windshield at various levels.

Many aspects of the proposed instrumentation are unique and will provide an unprecedented full scale record of wind-structure interaction parameters. Such instrumentation, though elaborate, is essential in order to reduce the uncertainties presently existing in the design. The present lack of sufficiently reliable parameters for the dynamic analysis of wind loading cannot be overcome by model testing because of the problems of scale, and particularly the inability to model the window-structure interaction involved.

(H.J. Price)