

# CONCRETE BARRIERS

## MANUFACTURING AND QUALITY CONTROL



# BARRIER MANUFACTURING YARD

## Full production in progress



# INTRODUCTION

- Why a concrete barrier manufacturing contract for SANRAL
- Vehicle restraint system chosen by SANRAL
- Access by construction companies working on road works work packages
- Extent of SANRAL road works work packages



# WHY A CONCRETE BARRIER MANUFACTURING CONTRACT?

- Extensive road upgrade work packages by SANRAL
- Requirement for an approved and functional vehicle restraint system (VRS)
- Future long terms use by SANRAL for road maintenance and construction



# EXTENT OF SANRAL ROAD WORKS PACKAGES

- N3 road construction – Pietermaritzburg to Spaghetti interchange Durban
  - Some 75km
- N2 road construction between Umdloti and Amanzimtoti
  - Some 55km
- Various current upgrade and repair work along N2 on south coast



# VEHICLE RESTRAINT SYSTEM SPECIFIED BY SANRAL

- Performance system was specified at tender stage
  - TL4W4 or H2/W4
- Deltabloc Proprietary product by Deltabloc South Africa was offered by successful tenderer and SANRAL accepted this offer
- Manufactured under license to Deltabloc South Africa
- Manufacturing done under a Contract awarded by SANRAL



# Barriers stacked, ready for upliftment

Stacking height had a big impact on logistics on site



# MANUFACTURED BARRIERS ISSUED TO CONTRACTORS AS FREE ISSUE EQUIPMENT

- Barriers issued to contractors appointed under various work packages
- Agreement between SANRAL and respective contractors for use of barriers as vehicle restraint systems
- SANRAL has an obligation to manage their assets





# CONCRETE BARRIER DETAILS

Barrier design

Barrier Specification



# CONCRETE BARRIER DESIGN (1)

- Barriers to perform as intended under crash conditions
- Definitions pertaining to concrete barriers
  - Vehicle restraint system
  - Errant vehicles
  - Barrier performance levels
    - Containment Level
    - Impact Severity
  - Working width



# Deltabloc barriers deployed at a construction site



## CONCRETE BARRIER DESIGN (2)

- Risk Management - SANRAL
- Risk Management - Contractor
- Design of barrier by the Proprietor based on specified containment levels
- Specified containment levels had acceptable risk management parameters



# CONCRETE BARRIER SPECIFICATION

- Specified performance level was for a portable double sided barrier with containment level H2/W4 or TL4/W4
- Barrier characteristics offered and accepted by SANRAL (DB80 Deltabloc system)
  - 6m long
  - 800mm high
  - 3500kg in weight
  - Fully interlocking system
  - Crash tested
  - Allows for a working width of 830mm



# Barriers stacked at manufacturing yard



# MANUFACTURING PROCESS

Manufacturing overview

Moulds for manufacture

Concrete requirements

Steel cages – Reinforcing

Manufacturing process



# MANUFACTURING OVERVIEW

- The Contractor opted to ready mix suppliers for concrete
- Barriers are manufactured as pre cast elements
- Manufacturing contract is in essence a factory production line
- Some 80km of barrier is required to be manufactured, comprising some 13500 concrete barriers
- The barrier Proprietor and the Client (SANRAL) has a vested interest in the deliverables under the mass production manufacturing process
- Proprietor – The barriers have to perform as crash tested as it is based on their design
- SANRAL – The barriers have to perform as crash tested as it was their decision to specify the particular barrier for use in the road reserve at construction site locations





# MOULDS FOR CASTING OF CONCRETE BARRIERS

- Barrier weight upon completion is some 3500kg
- Barrier is cast in a heavy duty mould
- Mould has to be prepared to accept reinforcing and proprietary linkage system, inclusive of release agent, unique numbering system for each barrier and a SANRAL logo on both sides
- Barrier is cast upside down and turned the right way up for demoulding
- Moulds have to be re used over the duration of the manufacturing contract
- Some 24 moulds were being used on 3 different cast yards on manufacturing site



# CONCRETE REQUIREMENTS

- SANRAL requires an exceptional lifespan from the manufactured barriers
- Durability concrete was specified – In terms of COLTO – W30/19
- Concrete workability had to suit casting of barriers as precast units
- Concrete early strength development was important to Contractor in to facilitate fast demoulding
- Strength development has to continue at rapid rate to facilitate moving and stacking of barriers without jeopardizing structural integrity
- Aesthetic appearance of concrete upon demoulding had to be acceptable
- Concrete strength of 30MPa had to be attained before barriers could be released for use.



## CONCRETE REQUIREMENTS (2)

- Durability tests required on concrete for every 500m of barrier cast per cast yard, of which there were 3:
  - Water sorptivity
  - Oxygen permeability
  - Chloride conductivity



# REINFORCING STEEL CAGES

- Steel cages were mass produced by Targeted Enterprise teams
- NOTE: The Contract required various Contractors Participation Goals to be achieved. This does not form part of this presentation detail
- Cages had to be fitted into moulds prior to casting with the required spacer blocks to ensure concrete cover where cover was one of the durability requirements



# QUALITY ASSURANCE AND CONTROL

Contractor's Quality Plan

Proprietor's responsibility

Engineer's site supervisory staff responsibility

Quality control process



# Casting of barriers in mould



# A typical cast yard with moulds being prepared



# Reinforcing steel cages ready for placing into moulds





# Reinforcing steel cages assembled



# A busy day at a casting yard



# CONTRACTOR'S QUALITY PLAN

- The quality plan had to cover all aspects of the work from materials procurement to manufacturing and final stacking of barriers in preparation of upliftment by the 3<sup>rd</sup> party contractors
- The Contractor had to prepare and submit a quality plan indicating in detail how he intended managing process control to achieve the required outcomes
- The Contractor's vested interest in the quality processes on site was that he had to deliver a product that was manufactured according to the set standards



# PROPRIETOR'S RESPONSIBILITY

- The Proprietor had a vested interest in the manufacturing process in that he guaranteed performance of the completed barriers under crash conditions and he was the designer of the barrier for which the crash test certificate was issued.
- The Proprietor had his own quality control staff on site to do quality inspections pertaining to the performance of the barriers manufactured.



# ENGINEER'S SITE SUPERVISORY STAFF RESPONSIBILITY

- The Engineer and his staff was deployed to site, not only to administer the Contract on behalf of the Employer but to ensure the following:
  - That a quality plan was developed for the manufacturing process
  - That the quality plan adhered to all the requirements pertaining to quality outcomes
  - That the quality plan of the Contractor was followed and implemented at all times
- The Engineering Site supervisory staff was present at each and every step of manufacturing, performing the following duties:
  - Visually assess the processes followed by the Contractor to ensure that his process control was properly implemented
  - Inspect the progress with manufacturing steps against hold point in the quality plan
  - Develop a full set of quality control documentation for each step in the manufacturing process for future reference should it be required



# QUALITY CONTROL PROCESS (1) – ASPECTS OF THE MANUFACTURING PROCESS MONITORED

- Concrete mix design approval
- Materials incorporated into the barriers
- Mould inspections for functionality and performance
- Assembly of reinforcement steel cages incorporated into the barriers
- Checking of concrete cover to steel reinforcement
- Checking that unique number template was in place
- Checking that SANRAL logo template was in place



## QUALITY CONTROL PROCESS (2) – ASPECTS OF THE MANUFACTURING PROCESS MONITORED

- Checking of application of shutter release agent which would assist with demoulding
- Each delivery of ready mix concrete saw a slump test performed and temperature of the mix at the delivery point taken
- Test cubes were made from each delivery to test strength development of the concrete
- NOTE: a laboratory was established on site to perform all the relevant concrete tests and checks
- Effectiveness of trowel finish o bottom of barriers after having been cast



## QUALITY CONTROL PROCESS (3) – ASPECTS OF THE MANUFACTURING PROCESS MONITORED

- Application of curing compound on exposed underside of cast barrier
- Early concrete strength development after 18 hours to ensure the required 7 -9Mpa strength was achieved to allow demoulding
- The demoulding process was monitored to ensure that barrier being demoulded with relatively “green concrete” does not get damaged
- Strength development on 7, 14 and 28 days to ensure that barriers could withstand the relevant interim handling processes
- Make sure that durability test blocks were cast every for every 500m of barrier manufactured per cast yard





## QUALITY CONTROL PROCESS (4) – ASPECTS OF THE MANUFACTURING PROCESS MONITORED

- Taking of core samples from durability test blocks to execute durability tests
- Cover depth measurements were taken randomly based on a predetermined sample size
- Minor repairs to be effected were checked and signed off
- Stacking of barriers were monitored to ensure that barriers handled and relocated



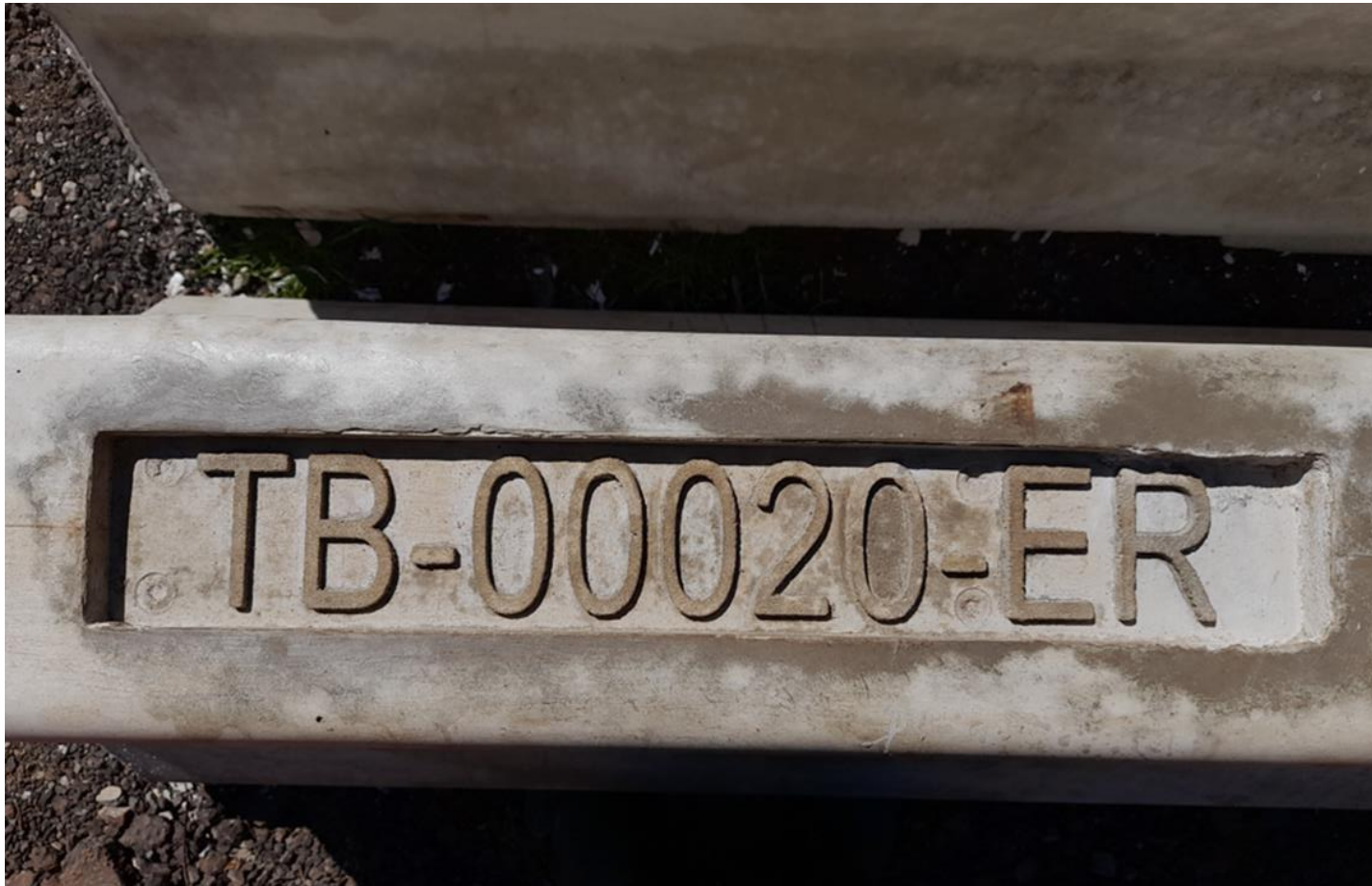
# Barrier being demoulded – Turning beam in action



# Mould ready to be cast



# Barrier numbering system



# QUALITY DATA BASE

- 2 data bases were developed for the manufacturing of the barriers
  - Concrete data base containing all the applicable concrete data for each barrier
  - Manufacturing data base for each barrier showing sign offs and approvals at various hold points for each step in the manufacturing process
- The history of manufacture for each barrier is traceable



# REMOVAL OF BARRIERS BY 3<sup>rd</sup> PARTY CONTRACTORS

- An agreement exists between SANRAL (asset owner) and contractor (end user) on the upliftment, transportation of, deployment, use and return of barriers central depot
- SANRAL expects the barriers to be re used over a period of some 20 years plus for road construction work and maintenance purposes



# RIGGING OF BARRIERS AT WORK PACKAGE CONSTRUCTION SITES

- Performance of the barriers once deployed is directly related to the quality of the rigging of the barriers on site
- The barriers have to be properly interlocked
- The footing conditions of the barriers are to be level or within performance tolerance for the locking mechanism
- Barriers must not be manhandled to the extent that its structural integrity is compromised



# Laboratory activities on site





# Additional Information – Deltabloc

- Vehicle Restraint Systems (VRS)
- Protect errant vehicles from deviating off the lane and minimize effects of accidents
- In Europe a VRS must meet requirements of European Norm EN 1317
- 3 main criteria of EN 1317 – Containment Level, Working Width, Impact Severity

Containment level



Restraint systems are classified by containment

Working width



Required space for the Vehicle Restraint System

Impact severity



Passenger protection

# ConPaveStruc 2023

29 & 30 AUGUST 2023

[www.cemcon-sa.org.za/conpavestruc2023](http://www.cemcon-sa.org.za/conpavestruc2023)

