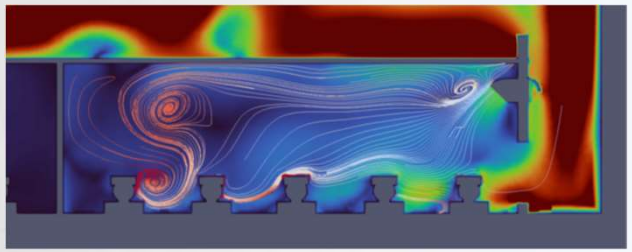
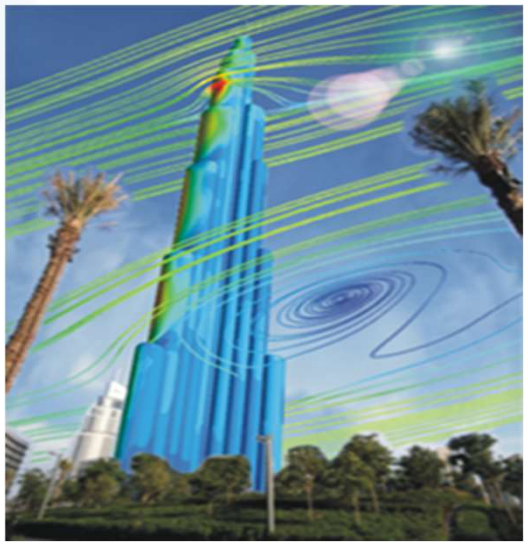
RBSANCHEZ PME CONSULTANTS & ASSOCIATES, INC.

www.rbs-engineers.com



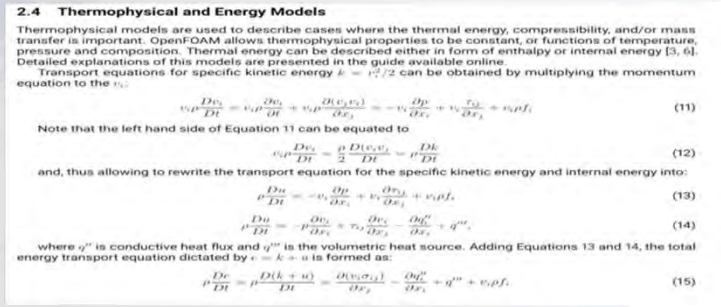


ROSENDO B. SANCHEZ, PME

MANAGING PRINCIPAL **APEC, ASEAN, PSME ENGINEER, Board**

UP Diliman BSME 1980 and PSME and TOME AWARDEE in Consultancy.

PRC BOARD EXAM M,E.TOPNOTCHER, 1ST Place, 1981,



2.4 Thermophysical and Energy Models

Thermophysical models are used to describe cases where the thermal energy, compressibility, and/or mass transfer is important. OpenFOAM allows thermophysical properties to be constant, or functions of temperature, pressure and composition. Thermal energy can be described either in form of enthalpy or internal energy [3, 6]. Detailed explanations of this models are presented in the guide available online.

Transport equations for specific kinetic energy $k = v_i^2/2$ can be obtained by multiplying the momentum equation to the v_i:

$$v_i \rho \frac{Dv_i}{Dt} = v_i \rho \frac{\partial v_i}{\partial t} + v_i \rho \frac{\partial (v_j v_i)}{\partial x_j} = -v_i \frac{\partial p}{\partial x_i} + v_i \frac{\tau_{ij}}{\partial x_j} + v_i \rho f_i \quad (11)$$

Note that the left hand side of Equation 11 can be equated to

$$v_i \rho \frac{Dv_i}{Dt} = \frac{\rho}{2} \frac{D(v_i v_i)}{Dt} = \rho \frac{Dk}{Dt} \quad (12)$$

and, thus allowing to rewrite the transport equation for the specific kinetic energy and internal energy into:

$$\rho \frac{Dk}{Dt} = -v_i \frac{\partial p}{\partial x_i} + v_i \frac{\partial \tau_{ij}}{\partial x_i} + v_i \rho f_i \quad (13)$$

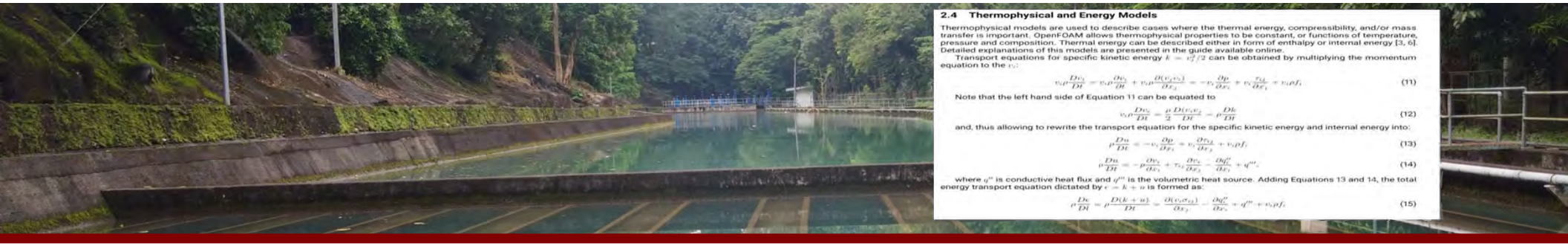
$$\rho \frac{Du}{Dt} = -p \frac{\partial v_i}{\partial x_i} + \tau_{ij} \frac{\partial v_i}{\partial x_j} - \frac{\partial q_i''}{\partial x_i} + \dot{q}'''. \quad (14)$$

where q'' is conductive heat flux and $\dot{q}'''$ is the volumetric heat source. Adding Equations 13 and 14, the total energy transport equation dictated by $e = k + u$ is formed as:

$$\rho \frac{De}{Dt} = \rho \frac{D(k+u)}{Dt} = \frac{\partial (v_i \sigma_{ij})}{\partial x_j} - \frac{\partial q_i''}{\partial x_i} + \dot{q}''' + v_i \rho f_i \quad (15)$$

CFD LIST OF PROJECTS

COMPUTERIZED FLUID DYNAMICS



2.4 Thermophysical and Energy Models

Thermophysical models are used to describe cases where the thermal energy, compressibility, and/or mass transfer is important. OpenFOAM allows thermophysical properties to be constant, or functions of temperature, pressure and composition. Thermal energy can be described either in form of enthalpy or internal energy [3, 6]. Detailed explanations of this models are presented in the guide available online.

Transport equations for specific kinetic energy $k = v_i^2/2$ can be obtained by multiplying the momentum equation to the v_i:

$$v_i\rho\frac{Dv_i}{Dt} = v_i\rho\frac{\partial v_i}{\partial t} + v_i\rho\frac{\partial(v_jv_i)}{\partial x_j} = -v_i\frac{\partial p}{\partial x_i} + v_i\frac{\tau_{ij}}{\partial x_j} + v_i\rho f_i \quad (11)$$

Note that the left hand side of Equation 11 can be equated to

$$v_i\rho\frac{Dv_i}{Dt} = \rho\frac{D(v_iv_i)}{2\ Dt} = \rho\frac{Dk}{Dt} \quad (12)$$

and, thus allowing to rewrite the transport equation for the specific kinetic energy and internal energy into:

$$\rho\frac{Dk}{Dt} = -v_i\frac{\partial p}{\partial x_i} + v_i\frac{\partial\tau_{ij}}{\partial x_j} + v_i\rho f_i \quad (13)$$

$$\rho\frac{De}{Dt} = -p\frac{\partial v_i}{\partial x_i} + \tau_{ij}\frac{\partial v_i}{\partial x_j} - \frac{\partial q''}{\partial x_i} + q''' \quad (14)$$

where q'' is conductive heat flux and q''' is the volumetric heat source. Adding Equations 13 and 14, the total energy transport equation dictated by $e = k + u$ is formed as:

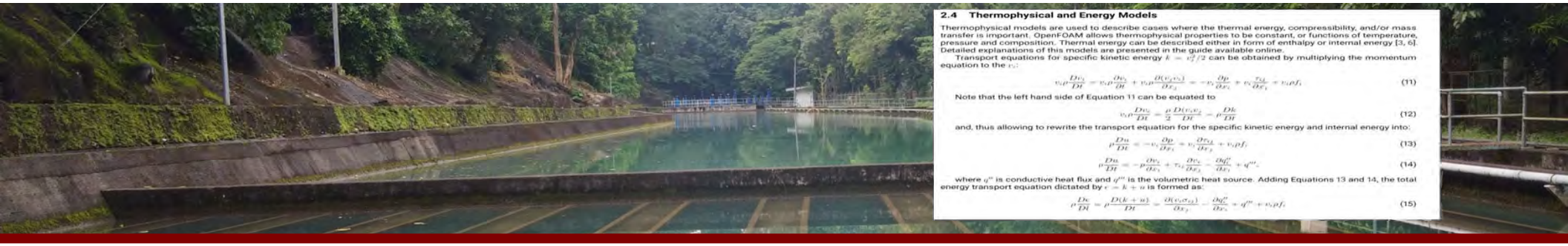
$$\rho\frac{De}{Dt} = \rho\frac{D(k+u)}{Dt} = \frac{\partial(v_i\sigma_{ij})}{\partial x_j} - \frac{\partial q''}{\partial x_i} + q''' + v_i\rho f_i \quad (15)$$

EXECUTIVE SUMMARY OF CFD EXPERIENCE AND RESOURCES:

RBS INC. HAS SIXTEEN (16 YEARS) OF CFD EXPERIENCE (since **2004 Shell Refinery CFD project**) and has participated in the **BURJ KHALIFAH** Dubai **CFD design project (2006-2007), WATER, LAKE AND RIVER SEDIMENT PUMPING, MINING PUMPING OF NON-NEWTONIAN FLUIDS, BINGHAM AND HETEROGENEOUS MOVEMENT OF LARGE SCALE SLURRIES, SLUDGE, VISCOUS FLUIDS, AND COOLING OF SERVER FARMS, LOCLEANROOMS, SMOKE AND POLLUTION STUDIES, ETC**. RBS have also done hundreds of CFD simulation consultancy projects (see company profile). Repeat and long-term clients have the confidence in the RBS experience as we have delivered reliable and COST-EFFECTIVE SOLUTIONS for over the last twenty (20) years. (See detailed project list).

LATEST SOFTWARE AND HARDWARE RESOURCES. RBS prefers to use **open source code software for HIGH FIDELITY, SITE-SPECIFIC CUSTOMIZATION** to fit project context and multitude of local mathematical variables. RBS has Three (3) units Hewlett Packard Proliant DL-380 Gen 3 Blade Servers 32-cores 3.0 MHz Intel Xeon Double Processors. However we may also use other specific software if the Client desires. (See hardware pics below).

RBS LEVERAGES THE BEST PHILIPPINE TALENT POSSIBLE FOR THE CLIENT PROJECT AS PROVEN IN PAST PROJECTS We have hired and commissioned experts (together with in-House RBS associates) in the fields of Structural, Civil, Mining, Metallurgical, Electrical, Chemical, Architectural, Geologist, Wasterwater. Reliablity Specialists, Operations and Maintenance Experts. etc. These multifaceted Fields of Expertise are required inputs in CFD works for real world simulations as all project variables and systems are interconnected and dynamic in reality. (See detailed bio-data below).



2.4 Thermophysical and Energy Models

Thermophysical models are used to describe cases where the thermal energy, compressibility, and/or mass transfer is important. OpenFOAM allows thermophysical properties to be constant, or functions of temperature, pressure and composition. Thermal energy can be described either in form of enthalpy or internal energy [3, 6]. Detailed explanations of this models are presented in the guide available online.

Transport equations for specific kinetic energy $k = v_i^2/2$ can be obtained by multiplying the momentum equation to the v_i:

$$v_i\rho\frac{Dv_i}{Dt} = v_i\rho\frac{\partial v_i}{\partial t} + v_i\rho\frac{\partial(v_jv_i)}{\partial x_j} = -v_i\frac{\partial p}{\partial x_i} + v_i\frac{\tau_{ij}}{\partial x_j} + v_i\rho f_i \tag{11}$$

Note that the left hand side of Equation 11 can be equated to

$$v_i\rho\frac{Dv_i}{Dt} = \rho\frac{D(v_iv_i}{2}\frac{)}{Dt} = \rho\frac{Dk}{Dt} \tag{12}$$

and, thus allowing to rewrite the transport equation for the specific kinetic energy and internal energy into:

$$\rho\frac{Dk}{Dt} = -v_i\frac{\partial p}{\partial x_i} + v_i\frac{\partial\tau_{ij}}{\partial x_j} + v_i\rho f_i \tag{13}$$

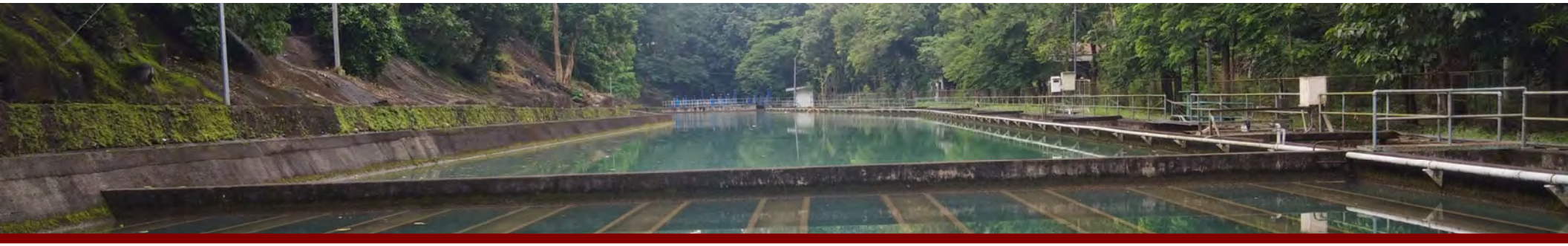
$$\rho\frac{De}{Dt} = -p\frac{\partial v_i}{\partial x_i} + \tau_{ij}\frac{\partial v_i}{\partial x_j} - \frac{\partial q''}{\partial x_i} + q'''. \tag{14}$$

where q'' is conductive heat flux and q''' is the volumetric heat source. Adding Equations 13 and 14, the total energy transport equation dictated by $\epsilon = k + u$ is formed as:

$$\rho\frac{D\epsilon}{Dt} = \rho\frac{D(k+u)}{Dt} = \frac{\partial(v_i\sigma_{ij})}{\partial x_j} - \frac{\partial q''}{\partial x_i} + q''' + v_i\rho f_i \tag{15}$$

SUMMARY OF CFD EXPERIENCE in PROJECTS:

SUCCESSFUL CFD EXPERIENCE FROM SMALL TO LARGE PROJECTS. LARGE SCALE sludge and mining pumps, PIPE AND RIVER Water and Wastewater TREATMENT Plants. The largest CFD done by RBS for **Manila Water is of 1,600MLD Balara Treatment Plant (BTP) Basin 1 and 2 facilities** Year 2019 to 2020. Largest for Pumping System Waterworks is the Maynilad Metro Manila Study for 120 Pump Stations done in 2018-2019. For Mining Industry is is the 120,000 ton per month Magnetite slurry pumping for JDVC Corp and Agbiag Mining in Cagayan 2021 to 2023. **Worldwide, the BURJ KHALIFA TOWERS Tallest building in the world** RBS has participated in the CFD setup, review and CFD development works of the Burj Tower**.** Lastly, the Largest for Cleanrooms is (7) hectare design of CLASS 100 area for **Western Digital Plant- a US Fortune 500 company in Laguna.** (See per project details below).



SOME RBS ACTUAL CFD CLIENTS :

Maynilad

SUNPOWER
FROM MAXEON SOLAR TECHNOLOGIES

Western Digital

TRANE

PLDT

Smart

HGST
a Western Digital company

F.F. CRUZ & CO., INC.
CIVIL & GEODETIC ENGINEERS • CONSTRUCTORS

FESTIVAL SUPERMALL
FILINVEST-ALABANG

starmall

ASYA

Kraft

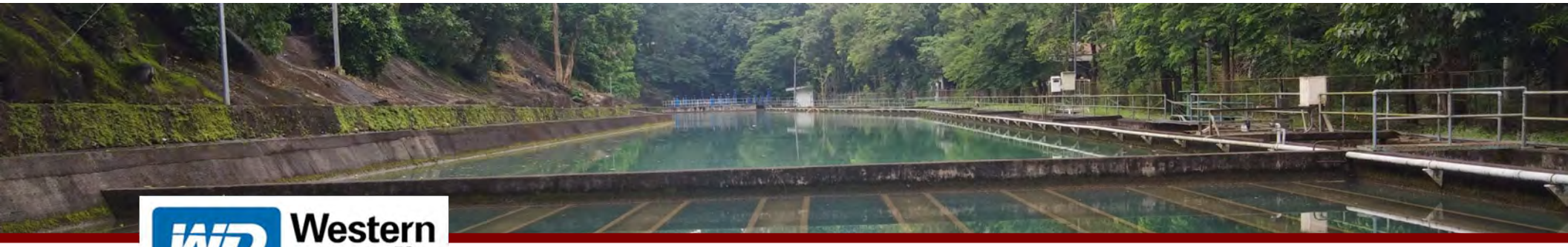
ASIAN HOSPITAL AND MEDICAL CENTER

ARCADIS

TOYOTA

JSLA
ARCHITECTS

ZAMA



Western Digital

SOME RBS ACTUAL CFD CLIENTS :

TRANE

MANILA WATER
CARE IN EVERY DROP

GHD

Chevron

First Balfour

AECOM

PHILIP MORRIS

RHi
ROXAS HOLDINGS, INC.

MEINHARDT PHILIPPINES, INC.

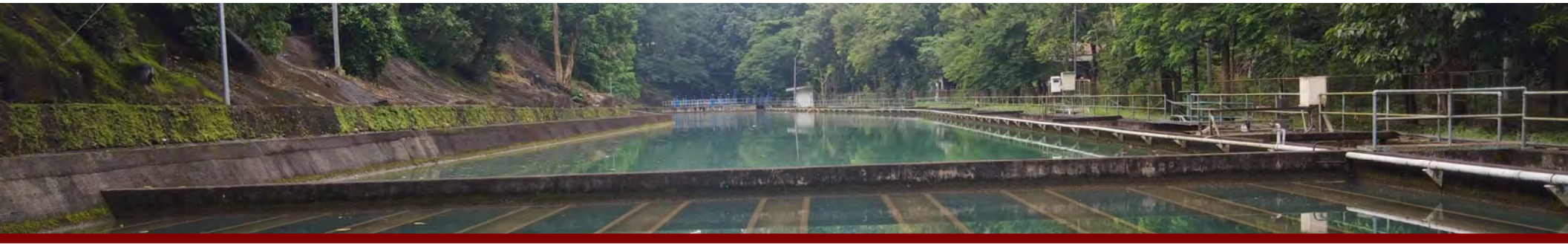
STIHL

Jollibee

ROBINSONS MALLS

JDVC Resources Corporation

Apollo Global Capital



CONTENTS

YCO CLOUD CENTER
Data Center (Philippines)

Light Industry and Science Park IV, Batangas
July 2023.

- **US$500M DATA CENTER to rise in Batangas** (2023 News Bulletin today)

12-MW YCO CLOUD DATA CENTER is certified to TIA 942 Rated III and ISO 22237

The design team is headed by U.S. based Gensler Architects and Manila-based JSLA Architects.

RBS is the CFD consultant.

.

- **RBS is responsible for the HVAC CFD Design Consultancy and Airflow/Ventilation Consultancy for DATA CENTER HALLS, SERVER RACKS and CABINETS, HVAC units,i.e. Precision CRAH/PAHU equipment Cooling Airflows and the external cooling of the high-power density 2.5MW multiple DIESEL GENERATORS as well as cooling of the mission-critical battery/UPS power supplies.**

CFD as part of the DESIGN SERVICES FOR 70,000 SQM SEMICONDUCTOR PLANT

HGST Plant. 109 Technology Ave SEPZ, Laguna Technopark
Sta Rosa, Laguna, 2022- 2023.

Western Digital
Delivering the possibilites of data

- **RBS CFD CONSULTANCY SERVICES for LAMINAR AIRFLOW of ISO CLASS 1OO. The 70,000 sqm WD PLANT EXPANSION for re design to capacity of 150million wafer semiconductor units.**

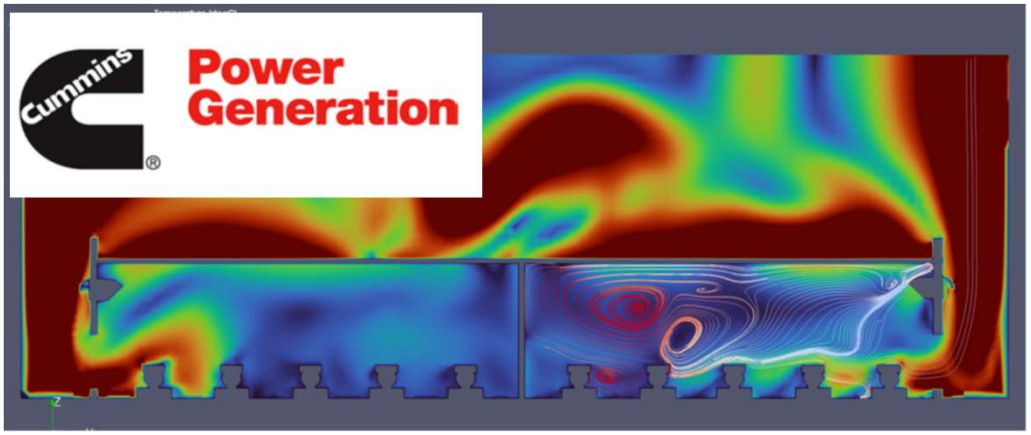
HGST
a Western Digital company

- **WD** has contracted **RBS as a "single-point responsibility"** for the engineering design of the plant's new 3000sqm CLEANROOM to ISO CLASS 1OO levels.

CFD CONSULTANCY SERVICES FOR CUMMINS 20MW POWER PLANT

PLDT DATA CENTER, Nicanor Garcia, Makati, Metro Manila. March 2023

- **RBS SUPERCOMPUTERS POWERS THE CFD STUDIES AND CONSULTANCY SERVICES FOR THE 20MW DIESEL POWER PLANT FOR AMAZON SERVER FARMS for CUMMINS AND PLDT.**



2.4 Thermophysical and Energy Models

Thermophysical models are used to describe cases where the thermal energy, compressibility, and/or mass transfer is important. OpenFOAM allows thermophysical properties to be constant, or functions of temperature, pressure and composition. Thermal energy can be described either in form of enthalpy or internal energy [3, 6]. Detailed explanations of this models are presented in the guide available online.

Transport equations for specific kinetic energy $k = v_i^2/2$ can be obtained by multiplying the momentum equation to the v_i:

$$v_i\rho\frac{Dv_i}{Dt} = v_i\rho\frac{\partial v_i}{\partial t} + v_i\rho\frac{\partial(v_j v_i)}{\partial x_j} = -v_i\frac{\partial p}{\partial x_i} + v_i\frac{\tau_{ij}}{\partial x_j} + v_i\rho f_i \tag{11}$$

Note that the left hand side of Equation 11 can be equated to

$$v_i\rho\frac{Dv_i}{Dt} = \frac{\rho}{2}\frac{D(v_i v_i)}{Dt} = \rho\frac{Dk}{Dt} \tag{12}$$

and, thus allowing to rewrite the transport equation for the specific kinetic energy and internal energy into:

$$\rho\frac{Du}{Dt} = -v_i\frac{\partial p}{\partial x_i} + v_i\frac{\partial \tau_{ij}}{\partial x_j} + v_i\rho f_i \tag{13}$$

$$\rho\frac{Du}{Dt} = -p\frac{\partial v_i}{\partial x_i} + \tau_{ij}\frac{\partial v_i}{\partial x_j} - \frac{\partial q_i''}{\partial x_i} + q''', \tag{14}$$

where q'' is conductive heat flux and q''' is the volumetric heat source. Adding Equations 13 and 14, the total energy transport equation dictated by $e = k + u$ is formed as:

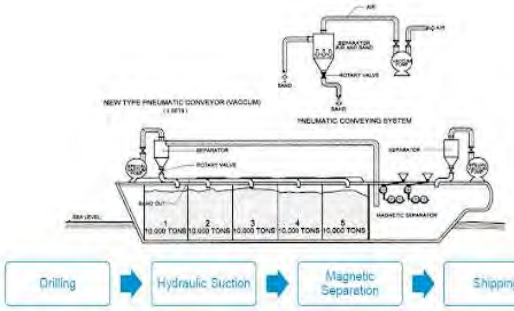
$$\rho\frac{De}{Dt} = \rho\frac{D(k+u)}{Dt} = \frac{\partial(v_i\sigma_{ij})}{\partial x_i} - \frac{\partial q_i''}{\partial x_i} + q''' + v_i\rho f_i \tag{15}$$

CFD FOR PUMPING OF HETEROGENOUS FLUIDS IN MINING OPERATIONS SERVICES FOR THE PHILS. LARGEST OFFSHORE MINING PROJECT

Offshore in Cagayan, Phillippines, Years 2021 and ongoing to 2023 ongoing.

- RBS supplies the CFD Mathematical Modelling and Mechanical Engineering expertise for for Offshore Pump Platform for Sand Extraction and On board MB Siphon 1 vessel of JDVC Corp.

- The operation requires a verical suction of heavy magnetitie particles of 120 meters depth on average and a pump power of 1MW sized pumps. Complete with three (3) full sets of magnetic separators, ejector system for deep-sea pump-up siphoning from down to 200 meters after the sea bed, washer apparatus, drying apparatus, and loading facilities for mineral transfer to export vessels. CFD for fluid flow and materials processing.



DESIGN AND CFD CONSULTANCY FOR ENVIRONMENTAL PROJECT EAST BAY WATER TREATMENT PLANT

Laguna Lake Reverse Osmosis Plant, Phillippines
Laguna Lake, August 2021

MANILA WATER
CARE IN EVERY DROP

First Balfour

- **RBS supplies consultancy for the CFD Engineering and environmental marine expertise** for the diffusion and dispersal of inflows and outflows from the Plant.

- **MANILA EAST BAY WATER TREATMENT RO PLANT**

  (REVERSE OSMOSIS plant) Tedagua with Philippine construction company First Balfour secured a contract in December 2020 for the design and construction of the East Bay Drinking Water Treatment Plant.

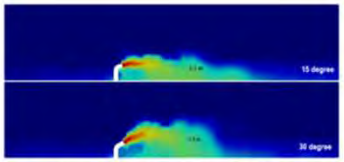


Figure 16. Comparison of brine dispersion at terminal heights reached by jet angles 15° and 30°

From the equation above, the extrapolated values coefficient for the Z/dF_0 of angles 15° and 30° yields to 0.1924215 and 0.6170892, respectively. **From these values, the resulting approximation terminal height Z, on both angles were 0.997 meters and 1.6520 meters that closely matches the results obtained from the fluid simulation** presented in figure 16.

Summary

The results of the far-field dilution values at 30° were similar to case 1 with insignificant density difference at same sample points. The major difference of the two cases were the terminal height. The terminal height or peak height reached by the plume were 1.7 meters compared to the 1.1 meters at case 1. It was observed as well that the impact dilution distance and near-field dilution were shorter than of case 1, implying that case 3 has lesser chance of re-circulation. But in the context of varying lake depths, the water level at the Laguna lake ranges from +2 meters minimum, +3.6 meters average and +5.1 meters maximum levels all in reference from the lake bed. With these depth values, +1.7 meters terminal height at 30° jet angle is still possible but with a high risk of lower dilution and faster transport due to surface current caused by stratified density depth layers and basically the free-surface waves and wind. At the case where the lake water level is at or below the minimum, high risk of re-circulation, stratification and progressive brine transport is likely to occur if the angle of jet is at 30°. Thus, it can be other angles such as 20° can be studied if the terminal height is acceptable with associated lower risk compared to this current case.

5.4 Case 4 - 30° jet inclination and underwater current

Similar to the approach done in case 2 and 3 to determine the significant changes, if there are, when the angles was changed to 30°. As observed from figure 17, the difference in the far-field dilution area was similar to that of case 2. It is presented in closer look in figure 18 that the diffusion shape is similar and the diffusion levels are also similar. The difference seems insignificant when compared in the far-field but can be observed to have minor differences in the concentration values in the near-field. Nonetheless, the difference were still insignificant aside from plume characteristics (thinner and longer) at 30° as seen in the plan view.

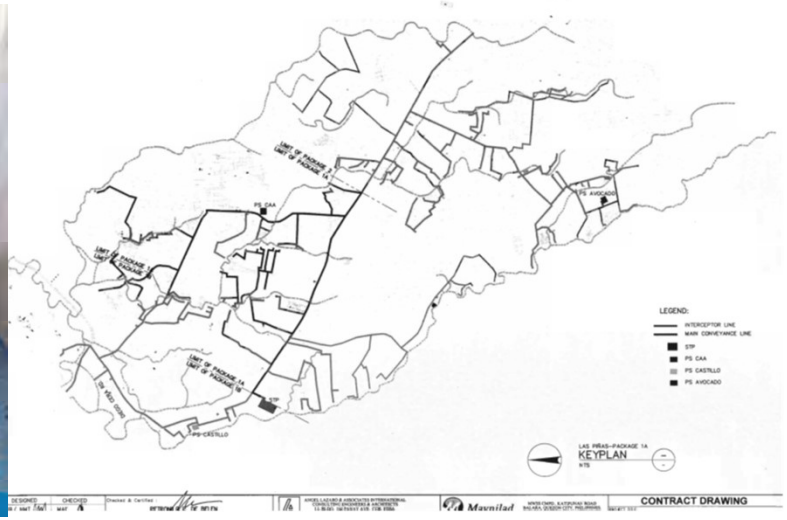
LAGUNA LAKE PROJECT. The contract is for the design and construction of a Drinking Water Treatment Plant (DWTP) sludge with a production capacity of 50,000m3 per day in the Pakil Lake area, Laguna Lake, east of Manila.

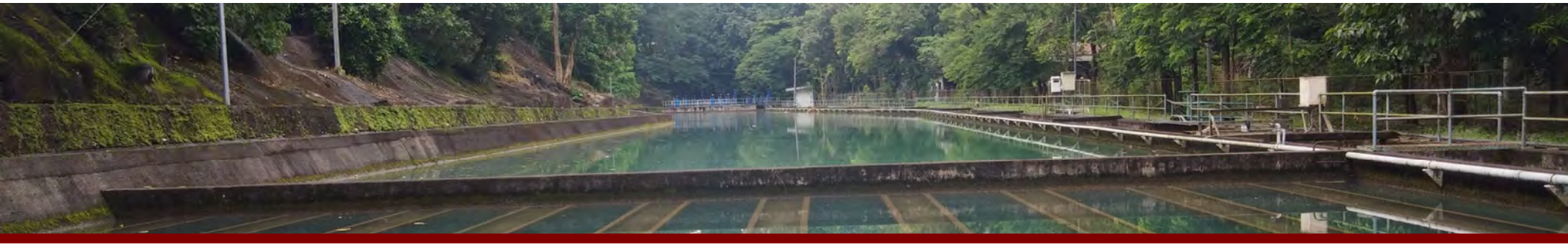
MAYNILAD LAS PINAS PUMPING STATION.

Las Pinas Maynilad, Paranaque City, Metro Manila, March 2022

- **CFD DESIGN and CONSULTANCY SERVICES for to be constructed 25 Million liters a day WATER PUMPING STATION AND PIPING.**

Scope is the Mechanical Pumping, Environmental, Structural, Civil, Safety, Sanitary and Fire Protection and Architectural services. April 2022

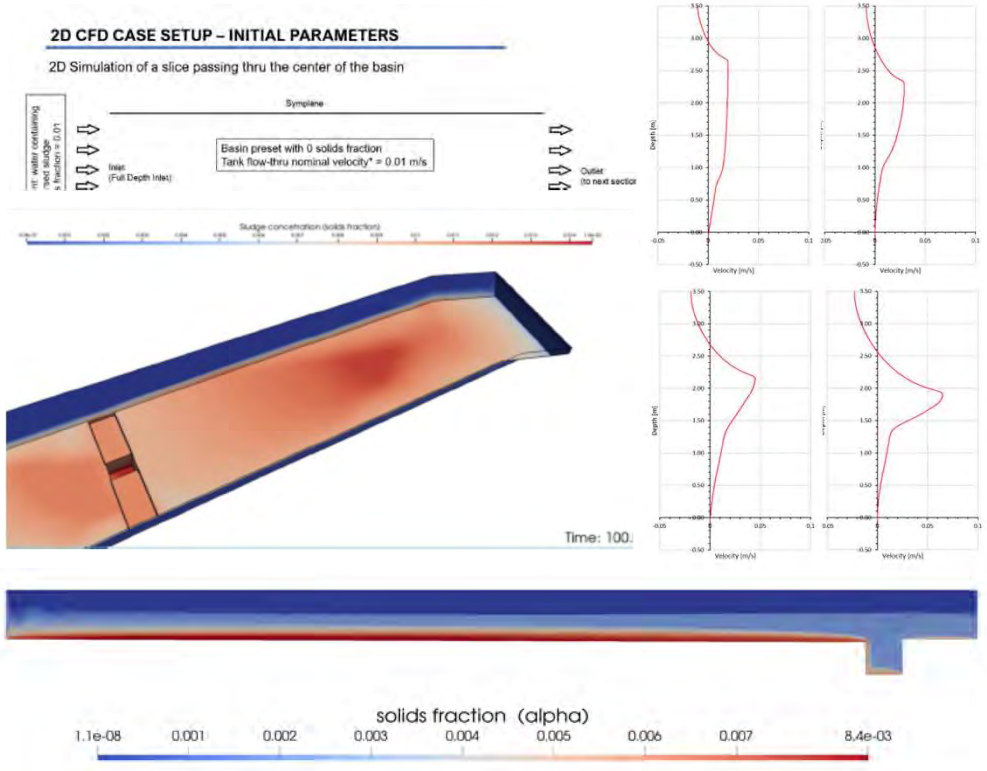




CONSULTANCY SERVICES FOR BALARA WATER TREATMENT PLANT 1

Solver: OpenFOAM v1902 – driftFluxFoam
Post-processing: Paraview

CFD simulation to predict the sedimentation through the basins and sludge accumulation. The results to be used as a confirmatory for design and reference for sludge pumping system. This includes parametric study of bed slopes and sludge pump pit intervals in the reference of velocity profile, effluent turbidity quality and concentration prediction along the depth of the basin.



MANILA WATER
CARE IN EVERY DROP

F.F. CRUZ & CO., INC.
CIVIL & GEODETIC ENGINEERS • CONSTRUCTORS
FF

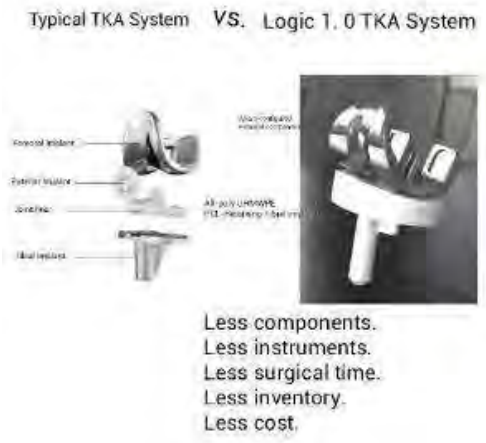
CFD CONSULTANCY SERVICES FOR CLASS 100 to CLASS 10,000 MEDICAL DEVICES CLEANROOMS

ARTHRO LOGIC, INC. Plant, Brgy. Fortune , Marikina City, MM, June 2021

- RBS is the HVAC PME Engineering Consultancy Services for the design and CFD of new Cleanrooms, and Controls system designer for the Plant.

  Project starts August 1, 2021.

- **ARTHRO LOGIC, INC. Plant will manufacture medical orthopedic devices and implants under Class 100 and 10k cleanroom conditions.**



Analysis of Gravity Induced Sludge Collection and Removal for Sedimentation Basin 1 and 2 of Balara Treatment Plant 1

RBSanchez PME Consultants and Associates Inc.[1]

[1]*RBSanchez Engineering Department, Makati Executive Tower 2, Makati, Manila*
Website: www.rbs-engineers.com

Executive Summary

Proposed sludge removal method for two continuous sedimentation basins were investigated prior to retrofitting. The initial system includes three sump pumps in pits at 60-m interval along the 180-m basin. The floor were sloped at 1:300 for gravity induced sludge transport.

CFD simulations were conducted to determine the behavior of pertinent parameters such as flow field, sludge detention, basin dimensions, sludge zone depth and rheological properties both for the accumulation period and during sludge removal operation. OpenFOAM solver driftFluxFoam was employed to perform the calculation for mass and momentum conservation for two-phase flow as a mixture. Applying the mixture model, water was set as the continuous phase and the settle-able sludge as dispersed phase. Furthermore, the sludge was modelled as a non-Newtonian fluid with rheological properties similar to bingham plastics. Measurements and validation tests were conducted to verify numerical solver predictions. Caution was exercised in using available data on best effort basis to represent actual site conditions.

The following items are summarized as the findings and corresponding recommendation, as proposed:

1. **Gravity-induced transport of sludge to the sump by floor slope of 1:300 is insufficient.** The initial design for sludge collection and removal will not be effective for long term operation. In this slope, the transport is very minimal that the sludge were accumulated in the interval span even after sludge pump operations.
   Recommendation: Increasing the slope to 1:150 to improve sludge transport without significant effect to the sedimentation process. Although, steeper slopes were observed to greatly improve the transport than 1:150 and shown in the concentration curves. Partial velocity disturbance and minor eddy formation may occur in the basin floor that may cause partial re-suspension in the floor depth.
2. **Shortened distance between sump pits will improve the sludge collection and removal.** Aside from increasing the slope, another parametric study findings in decreasing the interval was observed. It was observed that shortening the intervals significantly increases the collection rate overall as the area of removal is proportionally increased. However, further decreasing the interval may incur higher operational cost and maintenance cost as the sludge pumps would require regular maintenance due to its purpose.
   Recommendation: In-depth cost analysis are not included in this tender. Considering operational and maintenance cost, it is still recommended to reduce the interval up to 45-meter interval from the 60-interval. It is necessary to test run sludge operation to set optimum interval for each section of the basin so that issues previously discussed are avoided.
3. **The study were set to consider an initial inlet of 300 NTU turbidity condition, as provided to be one of the highest in record.** The study considered also a 100 NTU computational domain, however yields to insignificant findings difference compared to the 300 NTU domain, thus is not pursued further.
4. Adjust the floor slope of the sump pit section towards the pump base accordingly, to allow sludge movement in the sump pit to be drawn towards the pump and ensure sludge transport from the sides of the pit.
5. Selected pump specification (capacity and TDH) suffices as the sludge pump is operated intermittently to draw sludge out of the basin. In addition, verify the pump's capability at fluid viscosity.

Continuous Sedimentation CFD Analysis (2020)

REF: 11.2019/RBS-OM-SED-BAS-CFD-000A

Written by
Dino Dela Torre

A Numerical Solver for the Hydrodyanimcs of Sedimentation Process

OpenFoam solver driftFluxFoam was employed to perform the calculation for mass and momentum conservation for two-phase flow as a mixture. Applying the mixture model, water was set as the continuous phase and the settle-able sludge as dispersed phase. Furthermore, the sludge was modelled as a non-Newtonian fluid of rheological properties that behaves similar to bingham plastics.

Mixture Continuity Equation By assuming multi-phase flow as a pseudo multi-phase mixture, only one set of governing equations is needed in solver 'driftFluxFoam'. They are continuity equation and momentum equation for mixture and a continuity equation for dispersed phase. Theoretically, continuity and momentum equations can be derived from Eulerian-Eulerian model (Brennan 2001). Considering a two-phase flow, one phase is continuous basefluid and the other phase consists of dispersed solid particles. A continuity equation is required for each of the two phases:

$$\frac{\partial (\phi_f \rho_f)}{\partial t} + \nabla \cdot (\phi_f \rho_f U_f) = 0 \tag{1}$$

$$\frac{\partial (\phi_s \rho_s)}{\partial t} + \nabla \cdot (\phi_s \rho_s U_s) = 0 \tag{2}$$

where ρ_f and ρ_s are the densities of continuous phase and dispersed solid phase, respectively. ϕ_f and ϕ_s are the volume fractions of continuous phase and dispersed solid phase, respectively. U_f and U_s the velocities of continuous phase and dispersed solid phase, respectively.

If added (1) to (2), the result can be written as:

$$\frac{\partial (\phi_f \rho_f + \phi_s \rho_s)}{\partial t} + \nabla \cdot (\phi_f \rho_f U_f + \phi_s \rho_s U_s) = 0 \tag{3}$$

For the two-phase mixture, key properties and flow features can be estimated using (Ishii and Grolmes, nd):

$$\rho_m = \phi_f \rho_f + \phi_s \rho_s \tag{4}$$

$$U_f = U_{fm} + U_m \tag{5}$$

$$U_s = U_{sm} + U_m \tag{6}$$

$$\phi_f \rho_f U_{fm} + \phi_s \rho_s U_{sm} = 0 \tag{7}$$

where U_{fm} and U_{sm} are relative velocities of continuous phase and dispersed solid phase to the mixture, respectively. U_m is the velocity of the mixture.

Then the contents in the second bracket of (3) can be rewritten as:

$$\phi_f \rho_f U_{fm} + \phi_s \rho_s U_{sm} = \rho_m U_m \tag{8}$$

Therefore, (3), the continuity equation for the two phases can be written in a very similar form as that for a normal single phase flow:

$$\frac{\partial \rho_m}{\partial t} + \nabla \cdot (\rho_m U_m) = 0 \tag{9}$$

In solver 'driftFluxFoam', (9) is not used directly in any header files. However, it will be used implicitly in file 'pEqn.H' for pressure-velocity correction.

Mixture Momentum Equation Momentum equations for continuous and dispersed solid phases can be given as:

For the two-phase mixture, key properties and flow features can be estimated using (Ishii and Grolmes, nd):

$$\rho_m = \phi_f \rho_f + \phi_s \rho_s \tag{4}$$

$$U_f = U_{fm} + U_m \tag{5}$$

$$U_s = U_{sm} + U_m \tag{6}$$

$$\phi_f \rho_f U_{fm} + \phi_s \rho_s U_{sm} = 0 \tag{7}$$

where U_{fm} and U_{sm} are relative velocities of continuous phase and dispersed solid phase to the mixture, respectively. U_m is the velocity of the mixture.

Then the contents in the second bracket of (3) can be rewritten as:

$$\phi_f \rho_f U_{fm} + \phi_s \rho_s U_{sm} = \rho_m U_m \tag{8}$$

Therefore, (3), the continuity equation for the two phases can be written in a very similar form as that for a normal single phase flow:

$$\frac{\partial \rho_m}{\partial t} + \nabla \cdot (\rho_m U_m) = 0 \tag{9}$$

In solver 'driftFluxFoam', (9) is not used directly in any header files. However, it will be used implicitly in file 'pEqn.H' for pressure-velocity correction.

Mixture Momentum Equation Momentum equations for continuous and dispersed solid phases can be given as:

Free Surface For free surface, symmetry boundary is applied here. Similar to zeroGradient for scalars, the normal component is set to zero for vectors.

Physical Properties of Activated Sludge Sewage sludge exhibits Bingham Plastic behaviour as was shown from several studies. Two quantities need to be specified in order to characterise this rheology, namely the yield stress, τ_y, and the plastic viscosity, η. A constitutive relationship for settling velocity is also needed in order to carry out numerical simulations with the Drift Flux model.

Yield stress and plastic viscosity vary with concentration. Various authors as reviewed by (Casey and Newman 1983), have formulated exponential relationships for these quantities. They have the general form;

$$\Phi = aC^{b\alpha} \tag{21}$$

where Φ is the physical property in question, α is the solids fraction and a and b are constants. The exponent stet, C, is generally the natural logarithm base e, or the base 10.

The exponent from the experimentally derived settling velocity can be adjusted using equation 22. This essentially scales the physical properties of the sludge used in initial cases for other experiments.

$$\Phi = aC^{\frac{a_{in}-0.002}{a_{in}} b\alpha} \tag{22}$$

The coefficients used for the calculation of sludge properties from are summarized in Table 2 - 5. Several sets of sludge properties have been opted to determine extent of effects of their properties to the workability of the proposed sludge removal method. Since there are no sludge scrapers to be installed, sludge displacement have been left virtually on gravitational effects induced by basin floor sloping.

Table 2. Coefficients used to estimate sludge properties

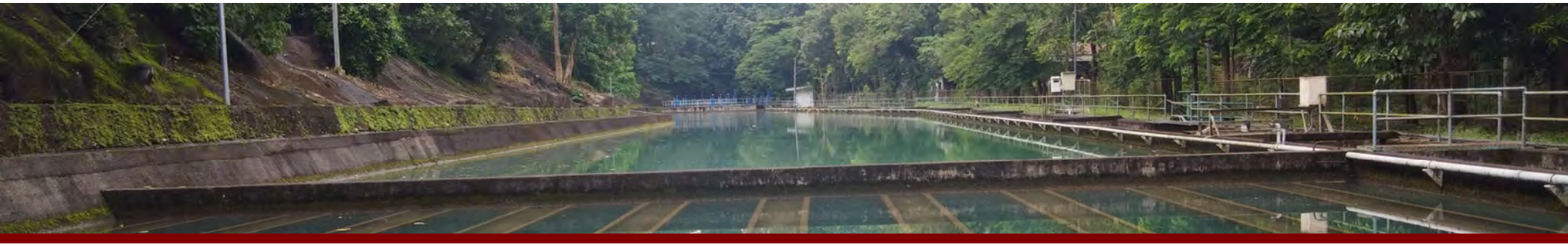
Property	Coefficient a		Exponent b	
			$\alpha_i n = 0.001$	$\alpha_i n = 0.002$
Yield Stress	5.55E-05	kg/(m.s^2)	1050.8	951.25
Bingham Viscosity	2.31E-04	kg/m.s	179.26	179.26
Settling Velocity	-2.20E-03	m/s	285.84	285.84

Table 3. Coefficients used to estimate sludge properties (low density)

Property	Coefficient a		Exponent b
			$\rho_d = 1042 kg/m^3$
Yield Stress	5.55E-05	kg/(m.s^2)	39.95
Bingham Viscosity	2.31E-04	kg/m.s	7.35
Settling Velocity	-2.20E-03	m/s	12.97

Table 4. Coefficients used to estimate sludge properties (medium density)

Property	Coefficient a		Exponent b
			$\rho_d = 2000 kg/m^3$
Yield Stress	5.55E-05	kg/(m.s^2)	951.25
Bingham Viscosity	2.31E-04	kg/m.s	179.26
Settling Velocity	-2.20E-03	m/s	285.84



CONSULTANCY SERVICES FOR BALARA WATER TREATMENT PLANT 1

MANILA WATER
CARE IN EVERY DROP

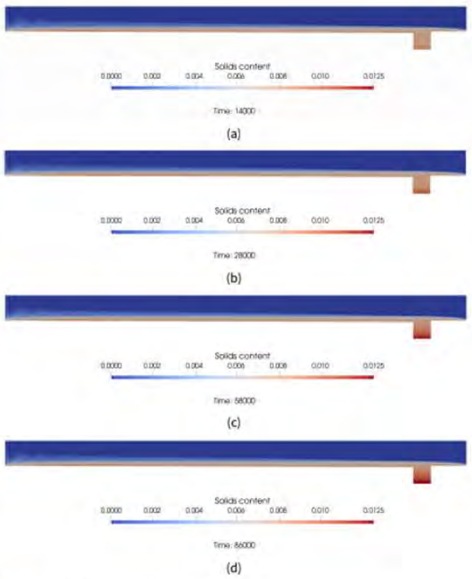


Figure 8. Sludge bed development after *t* hours

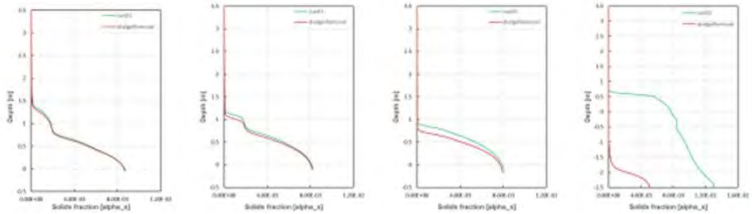


Figure 10. Sludge concentration along basin depth at different sections, *t* = 24 hours

OPTIMAL AND COST-EFFECTIVE SLOPE AND SUMP PIT INTERVALS

Using measurements and results of the CFD model, the recommendation is to have a basin bed slope of 1:300 at sump pit intervals every 60 meters. These figures were realized after series of parametric studies and cost effective solutions analysis.

Analysis of Gravity Induced Sludge Collection and Removal for Sedimentation Basin 1 and 2 of Balara Treatment Plant 1

RBSanchez PME Consultants and Associates Inc.[1]

[1]*RBSanchez Engineering Department, Makati Executive Tower 2, Makati, Manila*
Website: www.rby-engineers.com

Executive Summary

Proposed sludge removal method for two continuous sedimentation basins were investigated prior to retrofitting. The initial system includes three sump pumps in pits at 60-m interval along the 180-m basin. The floor were sloped at 1:300 for gravity induced sludge transport.

CFD simulations were conducted to determine the behavior of pertinent parameters such as flow field, sludge detention, basin dimensions, sludge zone depth and rheological properties both for the accumulation period and during sludge removal operation. OpenFOAM solver driftFluxFoam was employed to perform the calculation for mass and momentum conservation for two-phase flow as a mixture. Applying the mixture model, water was set as the continuous phase and the settle-able sludge as dispersed phase. Furthermore, the sludge was modelled as a non-Newtonian fluid with rheological properties similar to bingham plastics. Measurements and validation tests were conducted to verify numerical solver predictions. Caution was exercised in using available data on best effort basis to represent actual site conditions.

The following items are summarized as the findings and corresponding recommendation, as proposed:

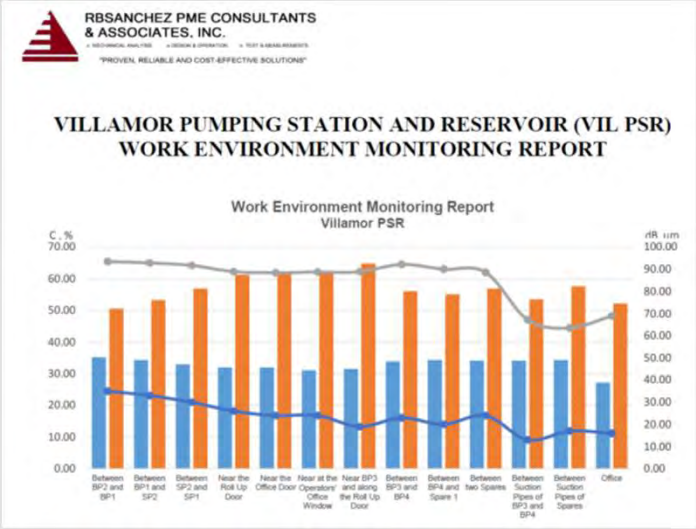
1. **Gravity-induced transport of sludge to the sump by floor slope of 1:300 is insufficient.** The initial design for sludge collection and removal will not be effective for long term operation. In this slope, the transport is very minimal that the sludge were accumulated in the interval span even after sludge pump operations. **Recommendation: Increasing the slope to 1:150 to improve sludge transport without significant effect to the sedimentation process. Although, steeper slopes were observed to greatly improve the transport than 1:150 and shown in the concentration curves. Partial velocity disturbance and minor eddy formation may occur in the basin floor that may cause partial re-suspension in the floor depth.**
2. **Shortened distance between sump pits will improve the sludge collection and removal.** Aside from increasing the slope, another parametric study findings in decreasing the interval was observed. It was observed that shortening the intervals significantly increases the collection rate overall as the area of removal is proportionally increased. However, further decreasing the interval may incur higher operational cost and maintenance cost as the sludge pumps would require regular maintenance due to its purpose. **Recommendation: In-depth cost analysis are not included in this tender. Considering operational and maintenance cost, it is still recommended to reduce the interval up to 45-meter interval from the 60-interval. It is necessary to test run sludge operation to set optimum interval for each section of the basin so that issues previously discussed are avoided.**
3. **The study were set to consider an initial inlet of 300 NTU turbidity condition, as provided to be one of the highest in record.** The study considered also a 100 NTU computational domain, however yields to insignificant findings difference compared to the 300 NTU domain, thus is not pursued further.
4. Adjust the floor slope of the sump pit section towards the pump base accordingly, to allow sludge movement in the sump pit to be drawn towards the pump and ensure sludge transport from the sides of the pit.
5. Selected pump specification (capacity and TDH) suffices as the sludge pump is operated intermittently to draw sludge out of the basin. In addition, verify the pump's capability at fluid viscosity.

ENVIRONMENTAL ASSESSMENTS OF ALL MAYNILAD PUMPING STATIONS

Maynilad

Maynilad Pump Stations in West Manila and Cavite | 2019

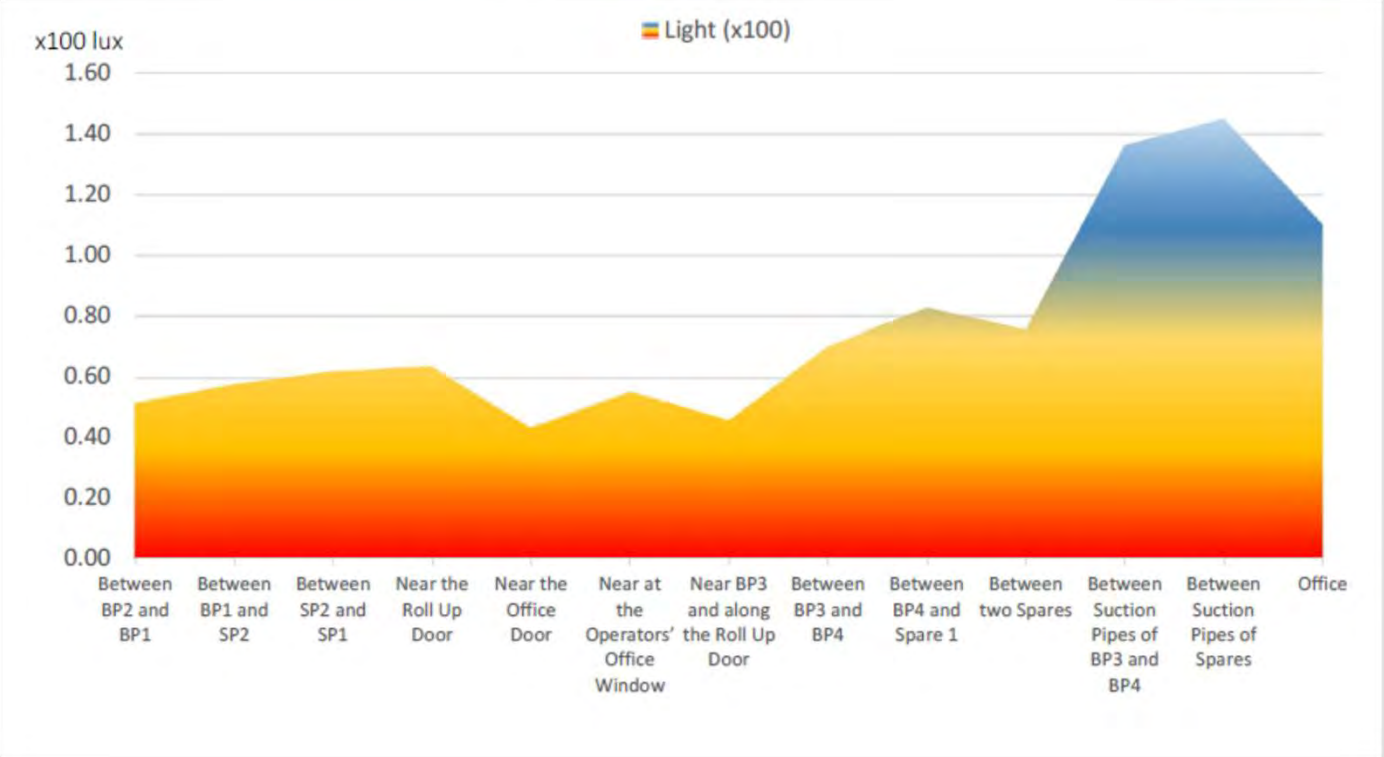
- RBSanchez Inc. is the Mechanical Consultant for the Maynilad Water HVAC and Environments System Assessments, measurements and Analysis of Building of pumping stations.



ENVIRONMENTAL ASSESSMENT OF PUMPS STATIONS

Maynilad

Maynilad Pump Stations in Manila and Cavite | 2019



CONSULTANCY SERVICES AND PUMP PERFORMANCE ASSESSMENT of MAYNILAD PUMP STATIONS

Maynilad Pump Stations in Metro Manila and Cavite | December 2018 to October 2019

- RBSanchez Inc. is the Mechanical Consultant for the Maynilad Water System Assessments, measurements and analysis for 120 pumping units in various pumping stations to 1100 hp water pumps.

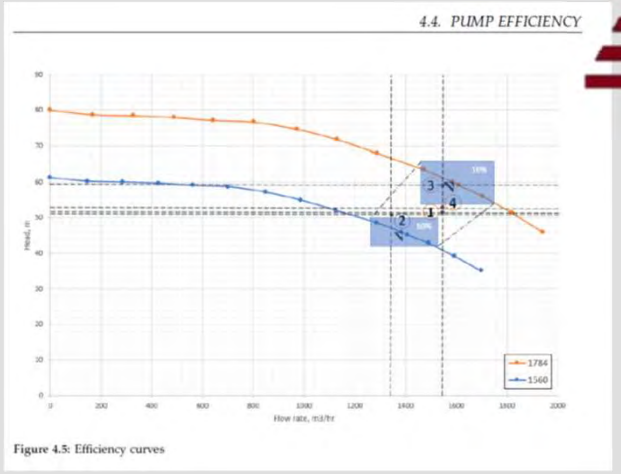
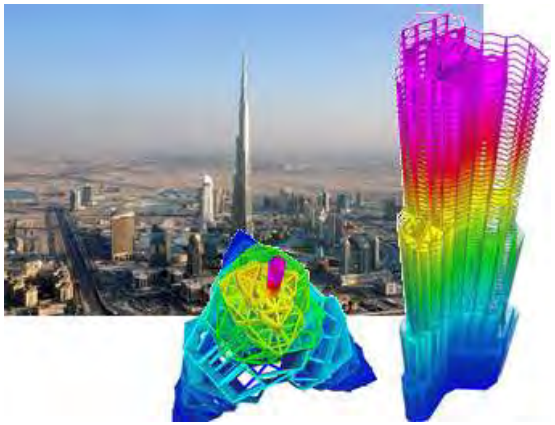


Figure 4.5: Efficiency curves

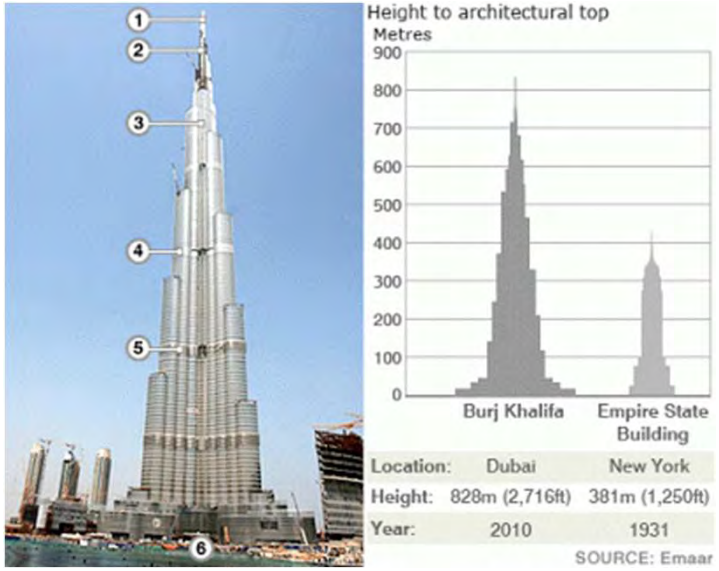
RBS contributes to the CFD designs for the TALLEST BUILDING IN THE WORLD



"WORLD'S TALLEST BUILDING" THE BURJ KHALIFA TOWER Dubai, UAE.

- Engr RBSanchez served as "HVAC DESIGN MANAGER"

Engr. Rosen Sanchez is the official signatory of all Khalifa Bldg HVAC and CFD construction drawings in the Year 2006-2007.



DESIGN OF VISCOUS PUMPING SYSTEMS OF LA CARLOTA SUGAR REFINERY

La Carlota Sugar Refinery, Negros Occidental | August 2020

- Tanks, Piping and pump system design using CFD simulation to predict and model the design of the VISCOUS FLUIDS behavior for molasses and magma pumping systems.

- RBSanchez Inc. is a long-term Partner with Global Horizons Inc. in various industrial projects.

CFD CONSULTANCY SERVICES FOR DESIGN OF GLAS TOWER PROJECT

Ruby St, Ortigas Commercial Center | Aug 2020

- RBS is the HVAC System Design Engineer and PME Consultant. For the first double-glazed, triple Low-E glass tower in Ortigas @ 188-meter with are of 102,000 square meters.

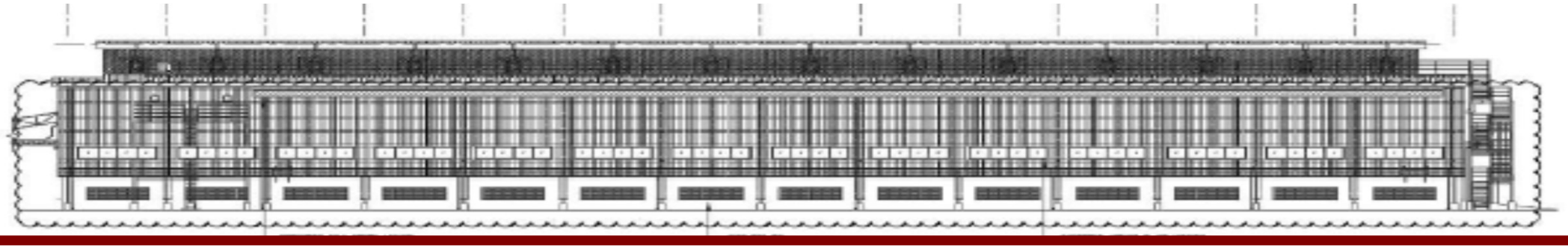
  Multi use building for BPOs, Offices and Hotel. (Year 2020)

RBSanchez Inc. is a long-term Asya Partner in Mechanical and Structural Design aspects of the Building.

COMPUTERIZED FLUID DYNAMICS (CFD) STUDIES of ZAMA PRECISION DIE-CASTING LINES

Completed Year 2020

RBSANCHEZ PME CONSULTANTS & ASSOCIATES, INC.
• MECHANICAL ENGINEERS • DESIGN • HVAC OPERATIONS & STUDIES
WWW. RBS-ENGINEERS.COM



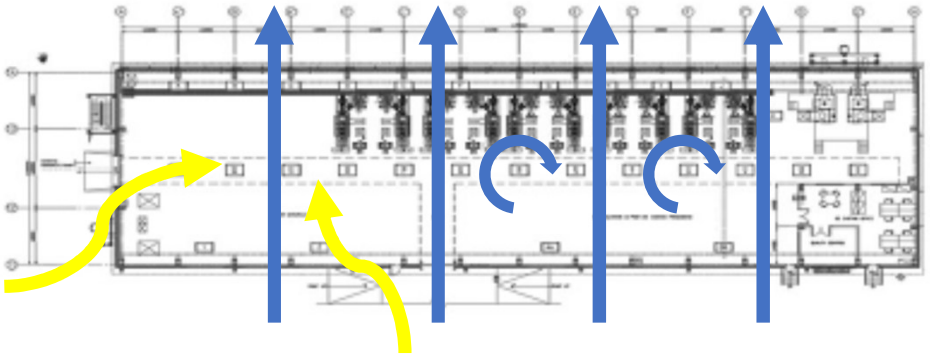
CFD ANALYSIS OF ALUMINUM-DIE CAST WAREHOUSE AT ZAMA PRECISION

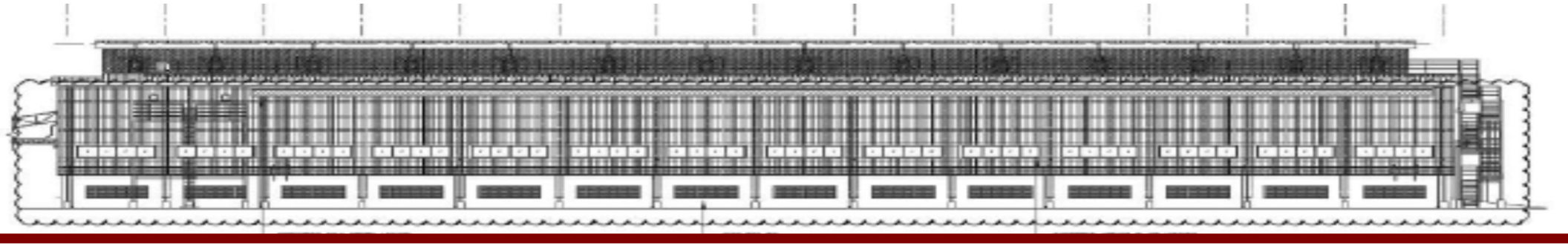
Solver: Fire Dynamic Simulation (FDS) Ver 6 and SmokeView and PyroSim

CFD simulation to solve the smog and high particle concentration PM2,5 inside the warehouse. Different options were designed and simulated to best address the air quality, including additional upper vents and enlargement of lower vents to follow natural buoyancy laws, cross-flow ventilations and local push-pull option as recommendation.

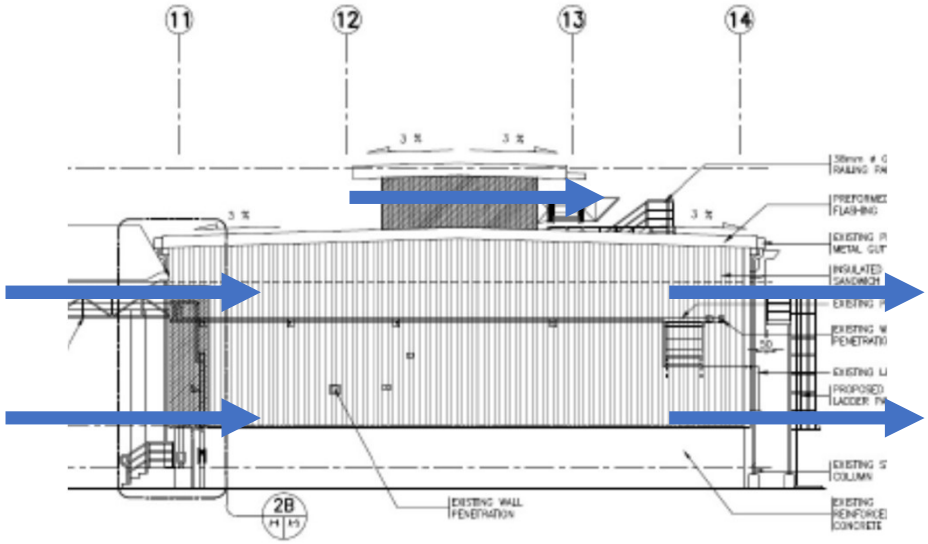
NO “CROSS VENTILATION” AT THE NORTHERN SIDE OF THE WAREHOUSE

Current velocity measurements shows that the air is only recirculating “plan-wise” (and not exhausting) across the building in the northern side near the furnaces.



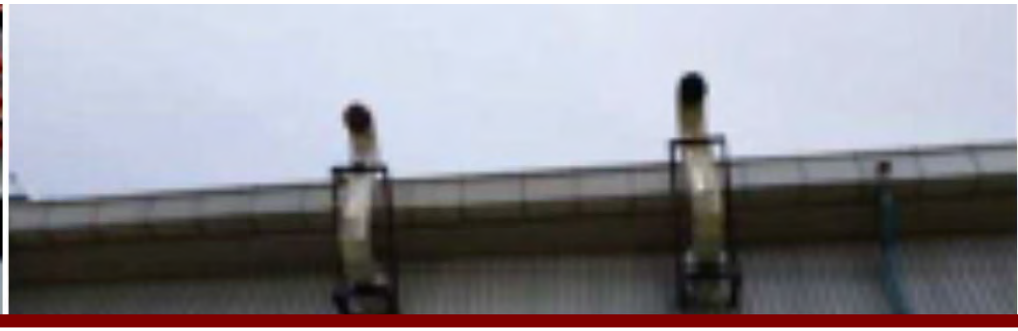


CFD ANALYSIS OF ALUMINUM-DIE CAST WAREHOUSE AT ZAMA PRECISION



NO "CROSS VENTILATION" AT THE NORTHERN SIDE OF THE WAREHOUSE

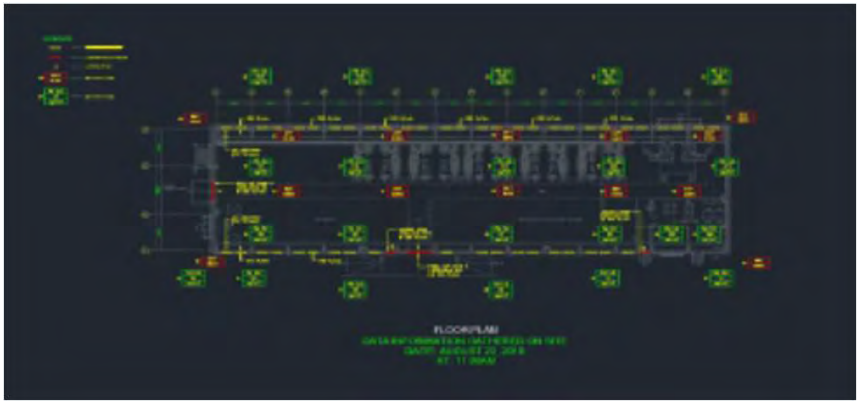
As a recommendation, we recommended to take advantage of the natural wind power at 322,900 cfm.

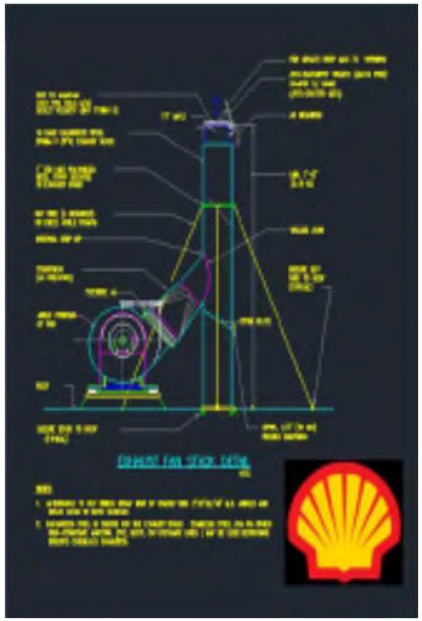


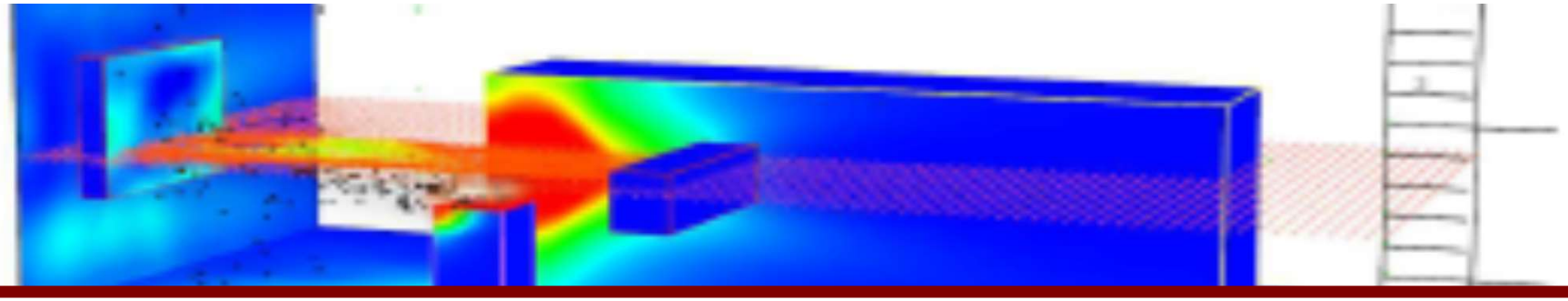
CFD ANALYSIS OF ALUMINUM-DIE CAST WAREHOUSE AT ZAMA PRECISION

PARTICLE ACCUMULATION OCCURS AT GROUND LEVEL OUTSIDE THE BUILDING AT NORTHEASTERN SIDE

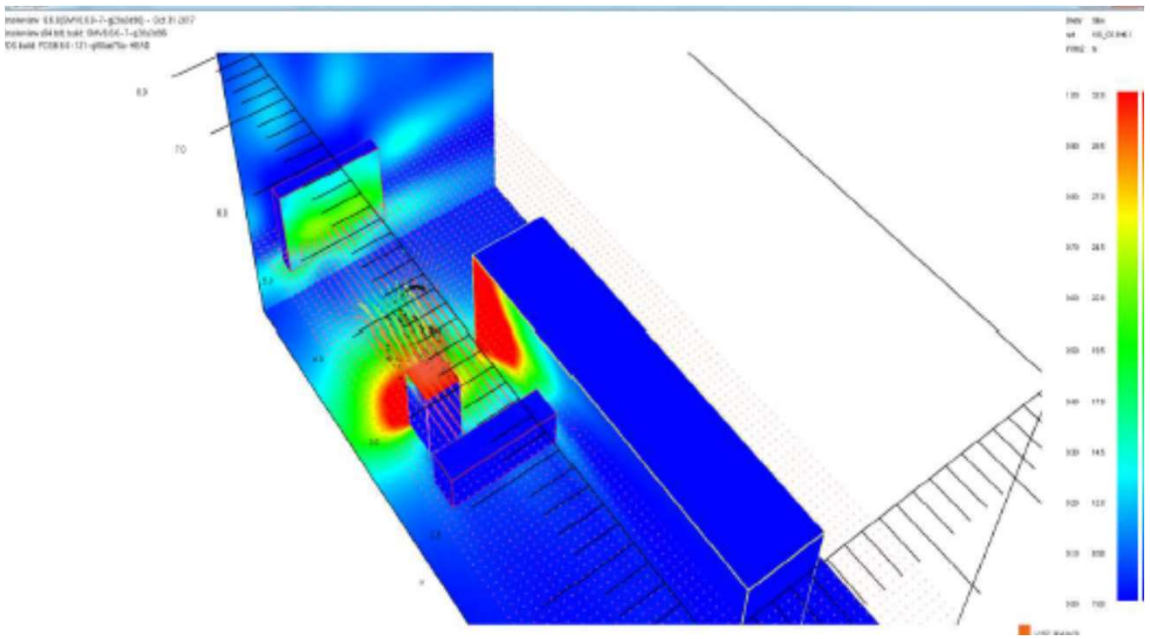
Particles on the rooftop tends to fall off due to the layout of the fans relative to the roof profile and the gooseneck exhaust layouts. As a standard, exhausted air and particles shall be vented to the atmosphere at high levels for proper dispersion. Particle readings show higher levels of PM2.5 matter in the area with 705 ug/m3 especially when furnace exhausts are in operation.

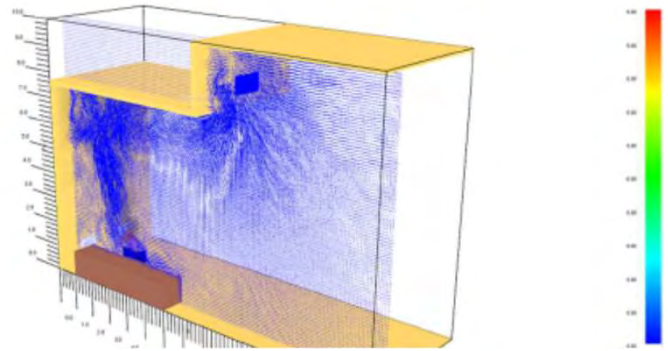






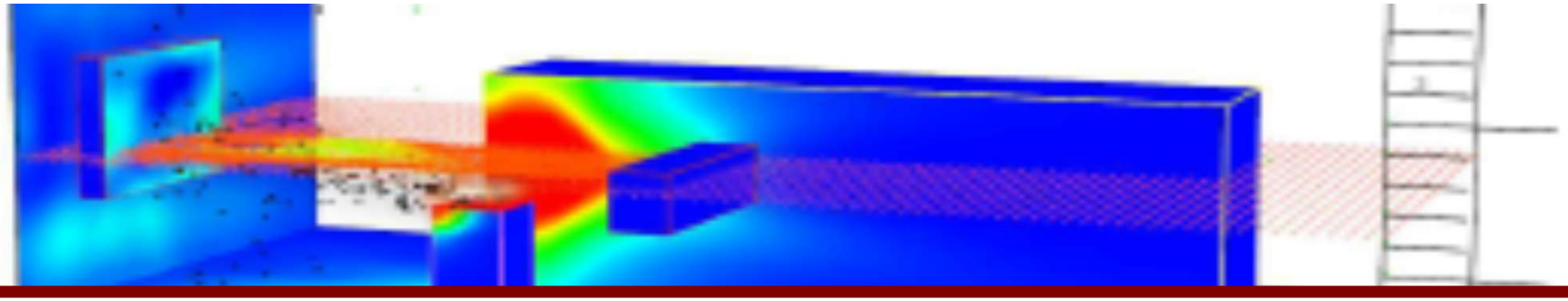
CFD ANALYSIS OF ALUMINUM-DIE CAST WAREHOUSE AT ZAMA PRECISION





LOCAL EXHAUSTS VENTILATIONS SUCH AS PUSH-PULL OPTIONS WITH MULTIPLE CFD SCHEMES

Different schemes were exercised and validated to identify the optimum solution for the exhaust of the particles from the furnaces. The following options were derived from different validated cases and studies and investigated if applicable in the warehouse situation.



CFD ANALYSIS OF ALUMINUM-DIE CAST WAREHOUSE AT ZAMA PRECISION

COMMENT ON THE PROPOSAL TO COMPLETELY INSULATE THE WAREHOUSE TO REDUCE INTERNAL TEMPERATURES

We were invited to comment on the proposal of insulating the warehouse. We don't recommend the insulation in the attempt to lower the internal temperatures of the warehouse, as it will only cost money, time, and space and moreover, increase the internal temperatures (not decrease).

However, we recommended high "solar reflectance" radiant barriers coupled with "air/insulation" technologies.

Actual CFD Simulations

CFD FOR FLUE GAS MODELLING

OF

SHELL REFINERY IN TABANGAO, BATANGAS

Done by RBS ASSOCIATE

ENGR FRANCISCO AMARRA

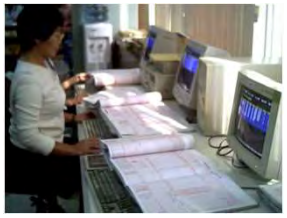
CFD FOR REFINERY GAS EMISSIONS IN SHELL TABANGAO REFINERY

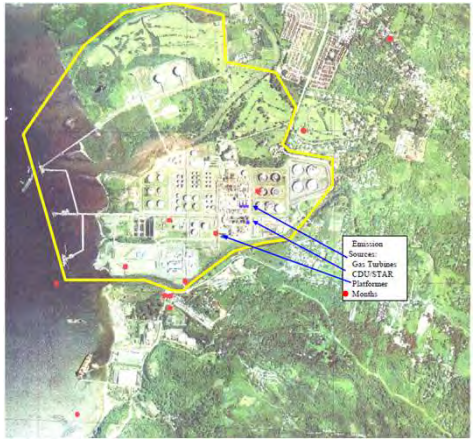
Program: AERMOD and AERMET

CFD analysis done by our associate Engr Francisco Amarra to study the SO_2 and NO_x concentrations from stack emissions in the Shell Tabangao Refinery

Input Data Required for AERMOD:

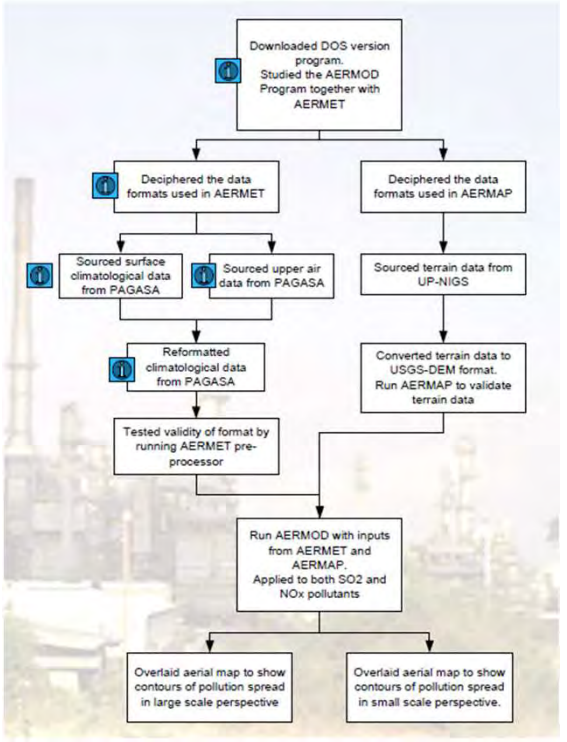
- Meteorological Pathways
  - –Site data for surface climate & upper air stations
  - –Study site data
- Surface Parameters
  - –Albedo, Bowen ratio, surface roughness
- **AERMAP**
  - –Terrain files converted to USGS-DEM format
- **AERMET**
  - –Raw data: Surface Climate } Surface File
  - –Raw data: Upper Air } Profile File





INPUTS AND DATA GATHERING ON THE TOPOGRAPHY

Detailed study in the area of study were conducted including the terrain mapping around the refinery using available data from different sources.



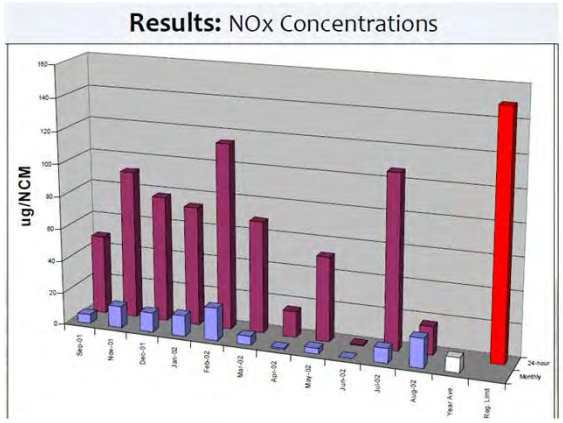
CFD CONSULTANCY SERVICES FOR DESIGN OF GLAS TOWER PROJECT

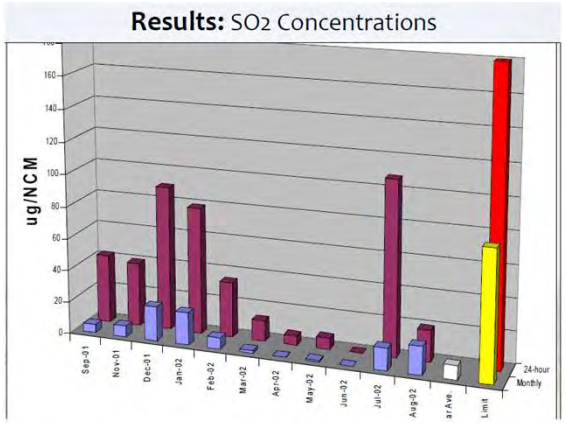
Ruby St, Ortigas Commercial Center | Aug 2021

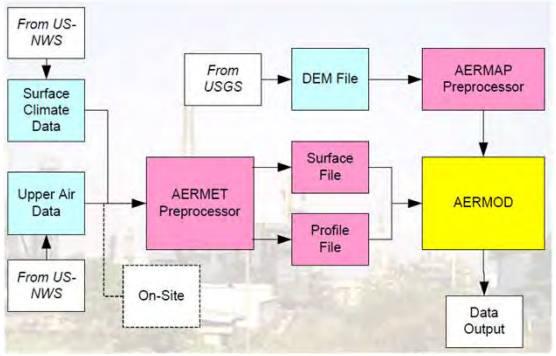
- RBS is the HVAC System Design Engineer and CFD PME Consultant. For the first double-glazed, triple Low-E glass tower in Ortigas @ 188-meter with are of 102,000 square meters.

  Multi use building for BPOs, Offices and Hotel. (Year 2020)

CFD FOR REFINERY GAS EMISSIONS IN SHELL TABANGAO REFINERY







RESULTS OF THE STUDY

Results shown above are the actual gathered and measured concentrations on site. The following concentrations are used for basis of calculations for recommendation and conclusion.

CFD FOR REFINERY GAS EMISSIONS IN SHELL TABANGAO REFINERY

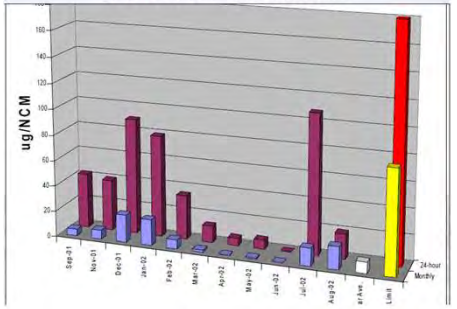
CONCLUSION

- Shell Tabangao Refinery emission concentrations were below the regulatory limits.
- Problems were encountered during acquisition of raw data:
  - Surface climate data not in required format;
  - Upper air climate data is not always available due to budget limitations
  - Terrain data is not readily available and expensive to produce.
- Conversion of raw data was successful. AERMOD program is applicable in the Philippines and was successfully applied using the Shell Tabangao Refinery.

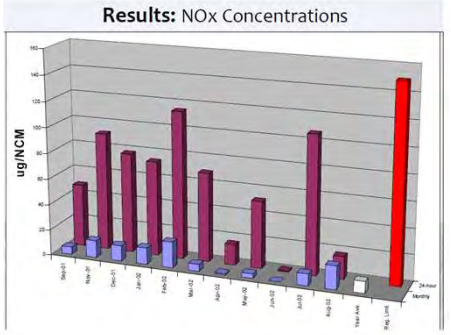
RECOMMENDATION

- **Air Dispersion Models** – EMB should focus on encouraging industries to make use of air modeling programs.
- **Surface and Upper Climatological Data** – bring up-to-date all encoding requirements for surface data and convert to CD-144 format: including encode of upper air data into CLICOM system and convert to TD-6201 formats
- **Terrain Data** – NAMRIA should develop digitized map in USGS-DEM format.

Results: SO_2 Concentrations

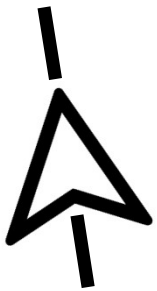


Results: NOx Concentrations



CFD ANALYSIS OF 5400-TR COOLING TOWER AT NEW FESTIVAL SUPER MALL

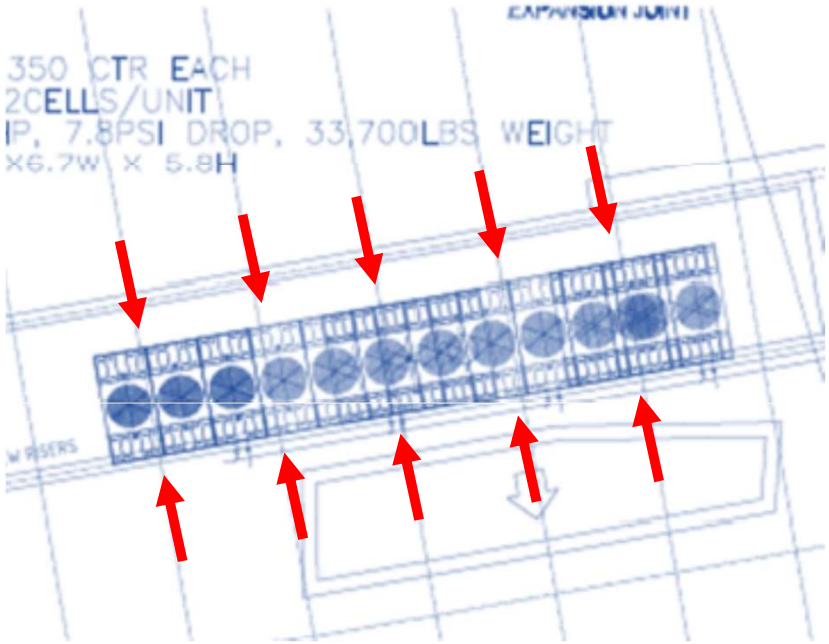
Different CFD schemes for the multiple configurations of the cooling towers based on orientation and layout arrangements. This includes single line tower configuration, separated towers at different tower orientation against prevailing wind direction.



WIND DIRECTION

OPTION 1 – SINGLE LINE TOWERS CONFIGURATION AT 90DEG AGAINST THE WIND

Aligned towers along the wind direction at one side of tower suction. This CFD run results to abnormal pressure changes on the back side due to the counter-acting forces from the wind blow and tower suction.



CFD DESIGN OF VISCOUS PUMPING SYSTEMS OF LA CARLOTA SUGAR REFINERY

La Carlota Sugar Refinery, Negros Occidental | July 2020

- Tanks, Piping and pump design with Fluid Dynamics and CFD simulation to predict the VISCOUS FLUIDS behavior for molasses and magma pumping systems.

- RBSanchez Inc. is a long-term Partner with Global Horizons Inc. in various industrial projects.

REA

5.0 COMMENT ON THE PROPOSAL TO COMPLETELY INSULATE THE FACILITY TO REDUCE INTERNAL TEMPERATURES. We were told to comment on the proposed insulation of the facility. We don't recommend these altogether if it is for for lowering of the internal temperatures. It will only cost money, time, and space and increase the internal temperatures.

We don't recommend using 150mm thermal insulation to reduce internal working temperatures.

We recommend high "solar reflectance" radiant barriers coupled with "air/ insulation" technologies.

CFD CONSULTANCY SERVICES FOR DESIGN OF GLAS TOWER PROJECT

Ruby St, Ortigas Commercial Center | Aug 2020

- RBS is the HVAC System Design Engineer and PME Consultant. For the first double-glazed, triple Low-E glass tower in Ortigas @ 188-meter with are of 102,000 square meters.

  Multi use building for BPOs, Offices and Hotel. (Year 2020)

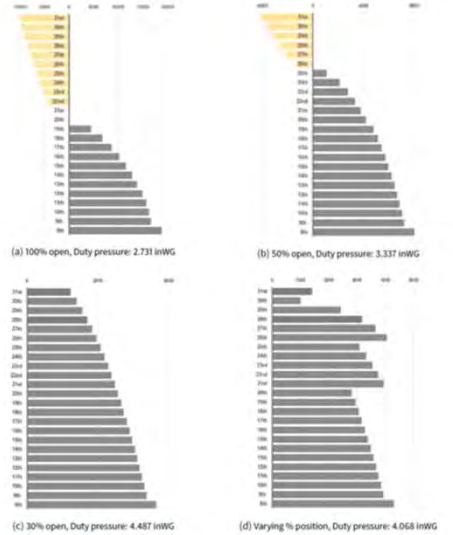


Figure 11. Volume air distribution at each floor supplied by the FAF-6F showing negative flow at shifting neutral plane as a function of damper opening

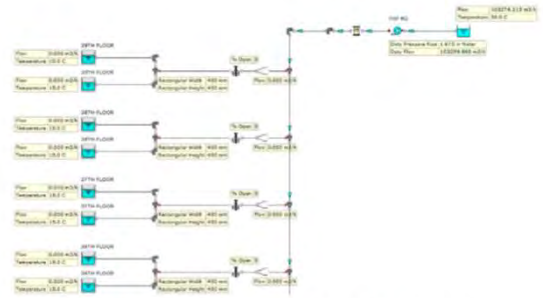


Figure 3. Network model of FAF-RD showing the floors with closed dampers

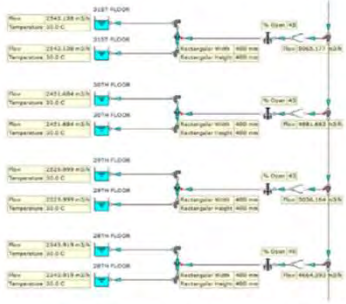


Figure 4. Continuation of the network model of FAF-RD showing 31st floor and below

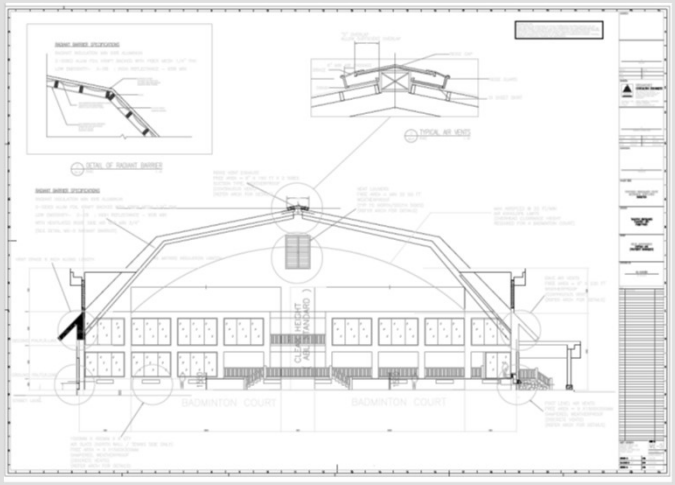
CFD DESIGN AND CONSULTANCY

"GREEN" NATURAL VENTILATION

TAGAYTAY HIGHLANDS BADMINTON COURT

Tagaytay City | 2006

- RBSanchez Inc. is the HVAC Design Consultant for the CFD NATURAL VENTILATION DESIGN OF THE SIX (6) INDOOR BADMINTON COURTS



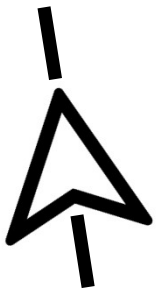
Actual CFD Simulations performed to date

FESTIVAL EXPANSION SUPERMALL

Alabang, Muntinlupa

CFD ANALYSIS OF 5400-TR COOLING TOWER AT NEW FESTIVAL SUPER MALL

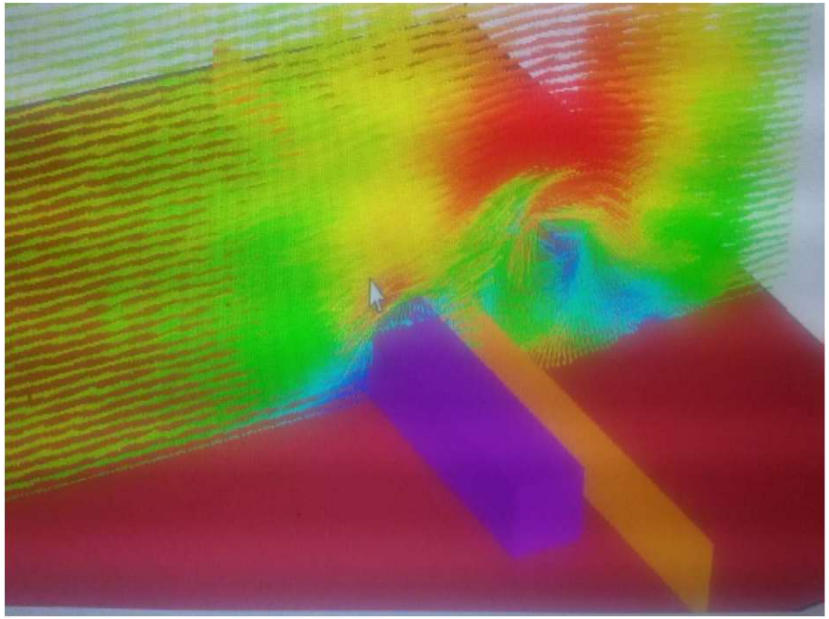
Different CFD schemes for the multiple configurations of the cooling towers based on orientation and layout arrangements. This includes single line tower configuration, separated towers at different tower orientation against prevailing wind direction.



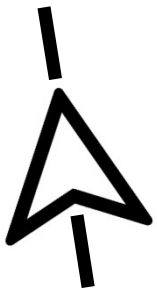
WIND DIRECTION

OPTION 1 – SINGLE LINE TOWERS CONFIGURATION AT 90DEG AGAINST THE WIND

Results show that abnormal backflow occurs at the back side of the cooling towers suction influenced by the suction of the tower flows.



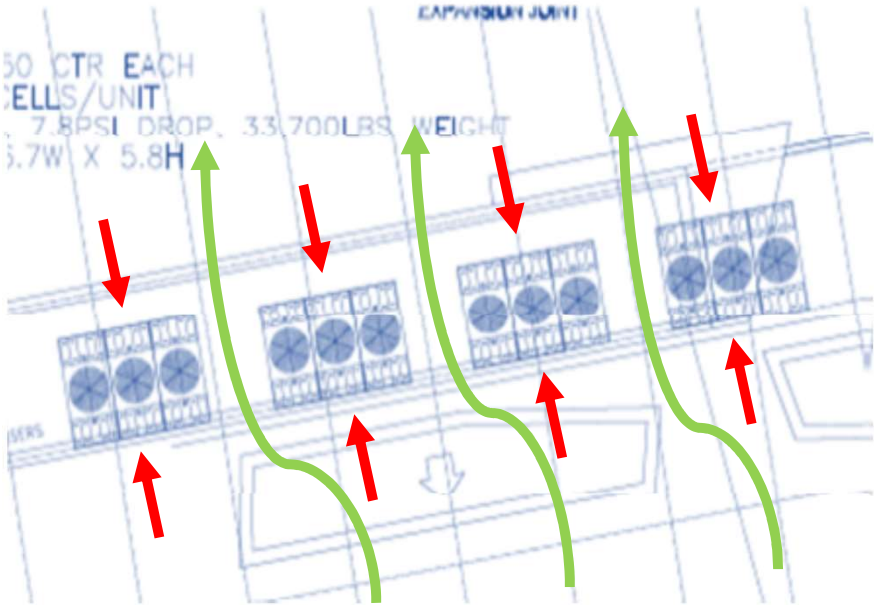
CFD ANALYSIS OF 5400-TR COOLING TOWER AT NEW FESTIVAL SUPER MALL



WIND DIRECTION

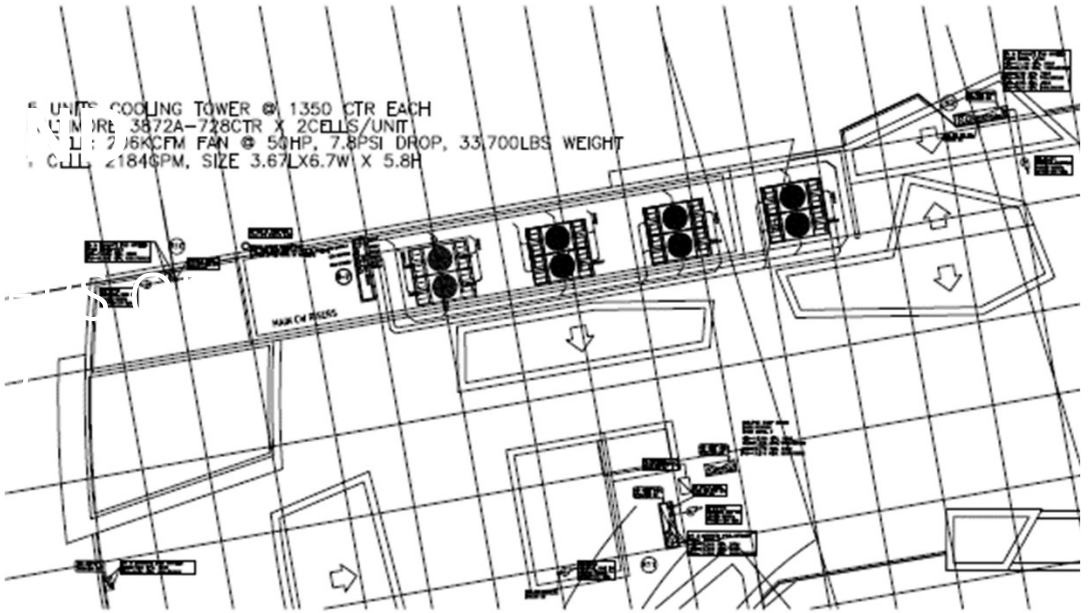
OPTION 2 – SEPARATED TOWERS CONFIGURATION AT 90DEG AGAINST THE WIND

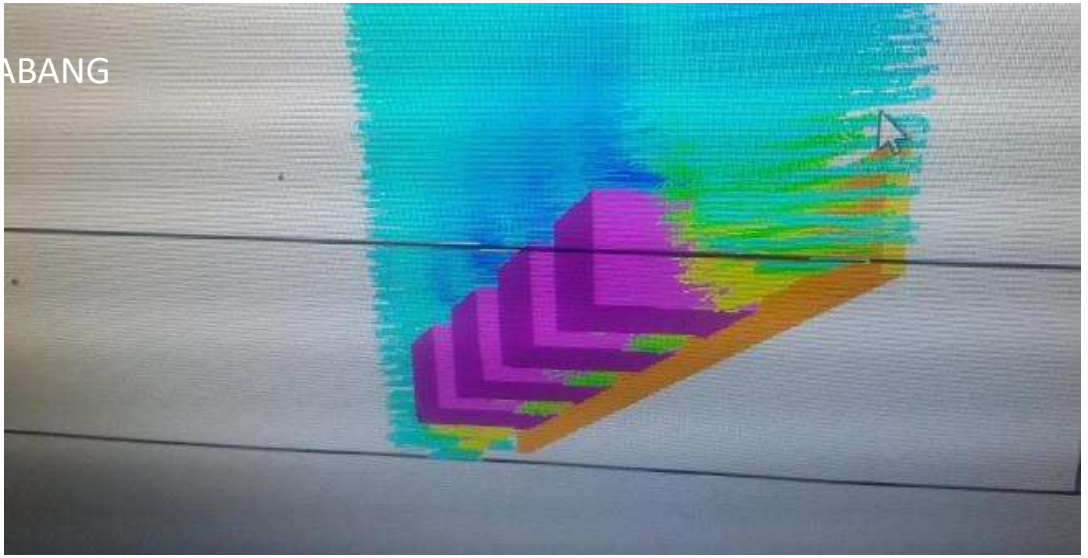
Same configurations except that the towers are separated to allow natural wind to flow between towers. Although improved airflow is observed in this case, abnormal pressure changes can still be observed in the back side of the towers suction.



FESTIVAL SUPERMALL

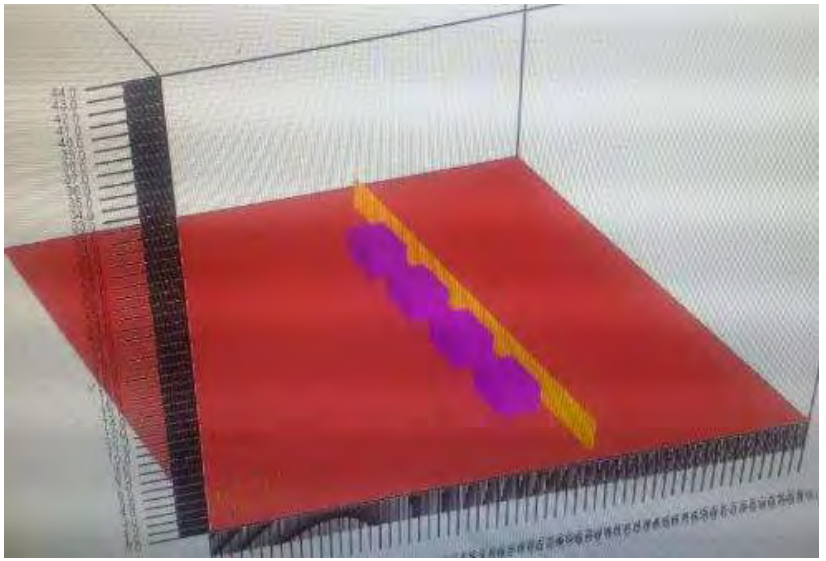
FILINVEST-ALABANG

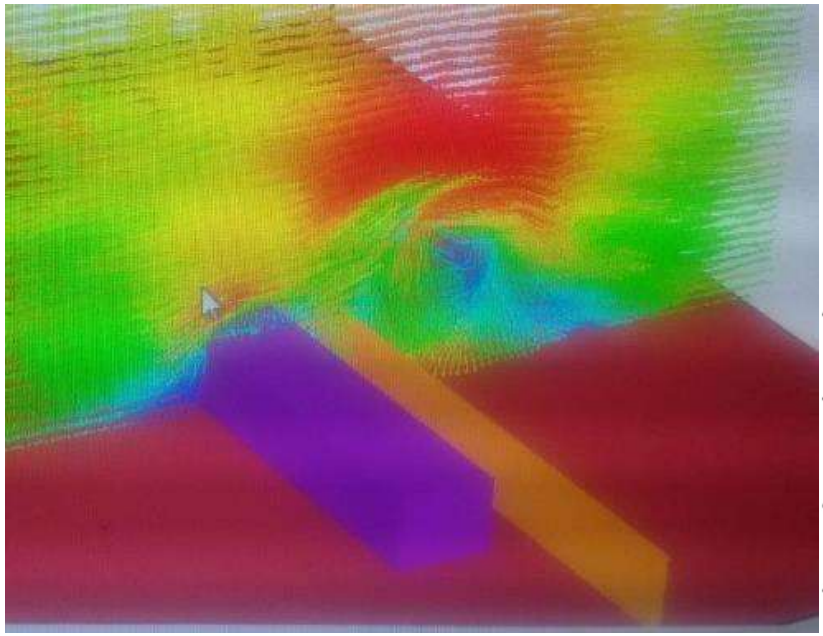


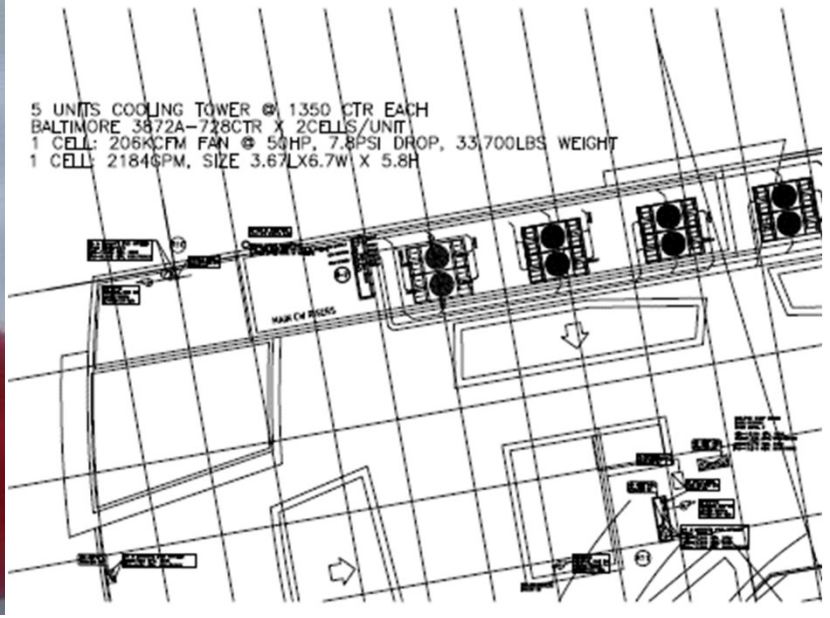


“AS DESIGNED” CFD RUN ON COOLING TOWERS

NEW FESTIVAL SUPER MALL

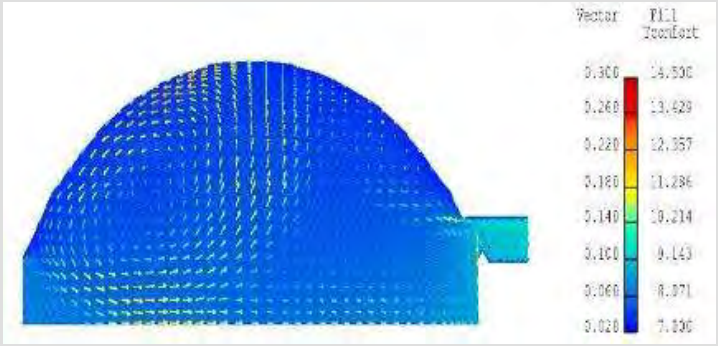


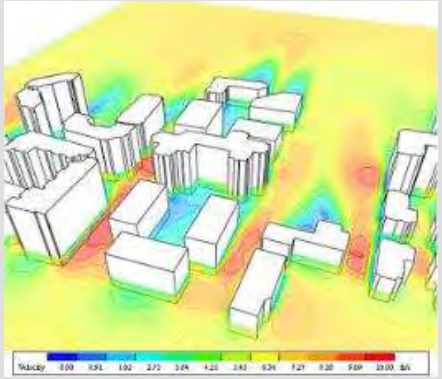


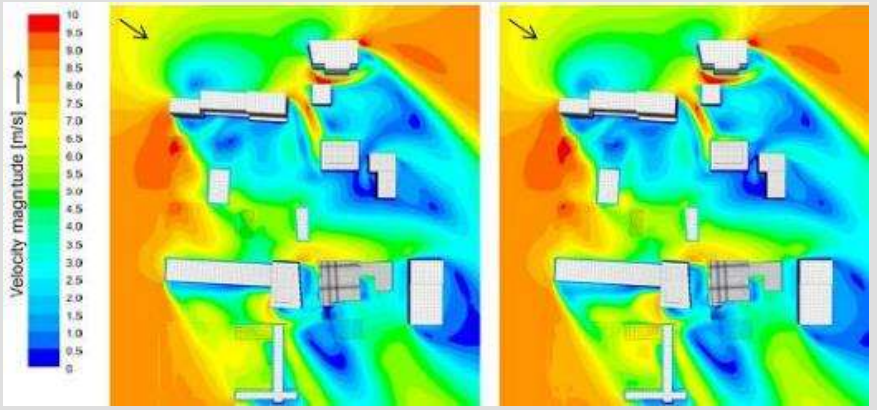


CFD DESIGN AND CONSULTANCY FOR STARMALL NATURAL VENTILATION

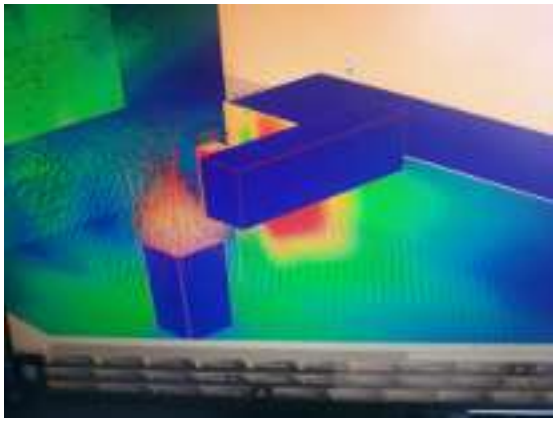
IMPROVEMENT PROJECT FOR METROPOLIS MALL AIR CAVERN CATCHER
CFD FOR NATURAL VENTILATION, ALABANG 2010



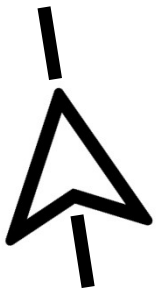




READINGS OF LOCAL VENTILATION PM2.5 PARTICLE CONCENTRATIONS



CFD ANALYSIS OF 5400-TR COOLING TOWER AT NEW FESTIVAL SUPER MALL

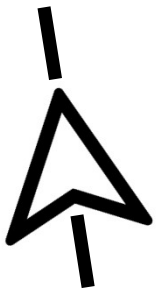


WIND DIRECTION

OPTION 3 – SEPARATED TOWERS CONFIGURATION AT 0DEG AGAINST THE WIND

Same configuration with the option 2 but with 0 degree orientation to the wind direction. In this configuration, the velocity profile shows good agreement and results at the downstream profile. Separation of towers and both suction faces results to almost uniform flow and acceptable pressure domains.

CFD ANALYSIS OF 5400-TR COOLING TOWER AT NEW FESTIVAL SUPER MALL

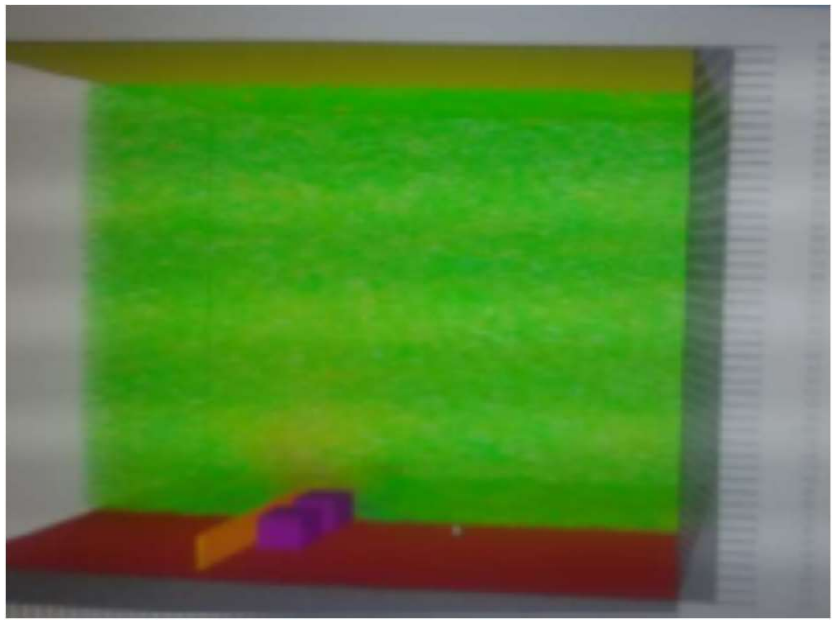


WIND DIRECTION

OPTION 3 – SEPARATED TOWERS CONFIGURATION AT 0DEG AGAINST THE WIND

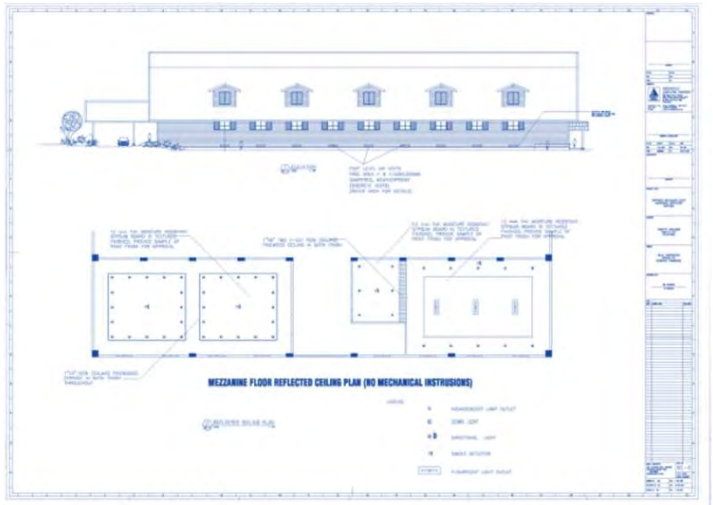
This configuration shows good agreement compared to previous cases and options. Additionally, this case shows most improved airflow profile upstream and downstream.

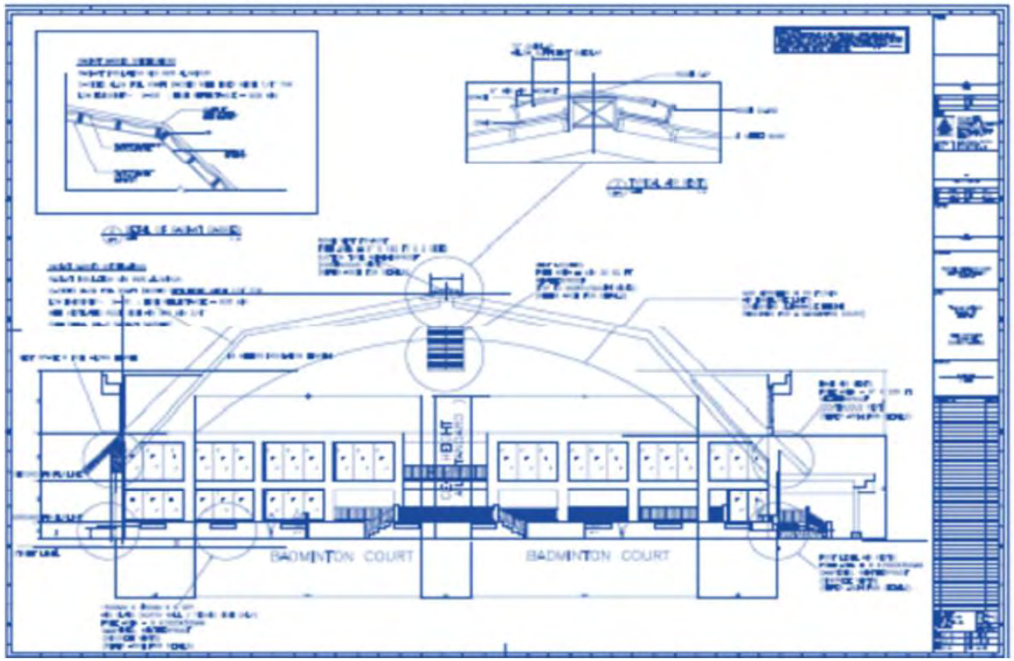
Thus, this option is the best configuration and was recommended to be tower layout and configuration.



CFD ANALYSIS AND CALCULATION FOR TAGAYTAY HIGHLANDS NATURAL VENTILATION

Under roof solar shield with 13mm hot air gap for insulation, huge solar cap covers and cross flow air ventilation and high ridge vents.



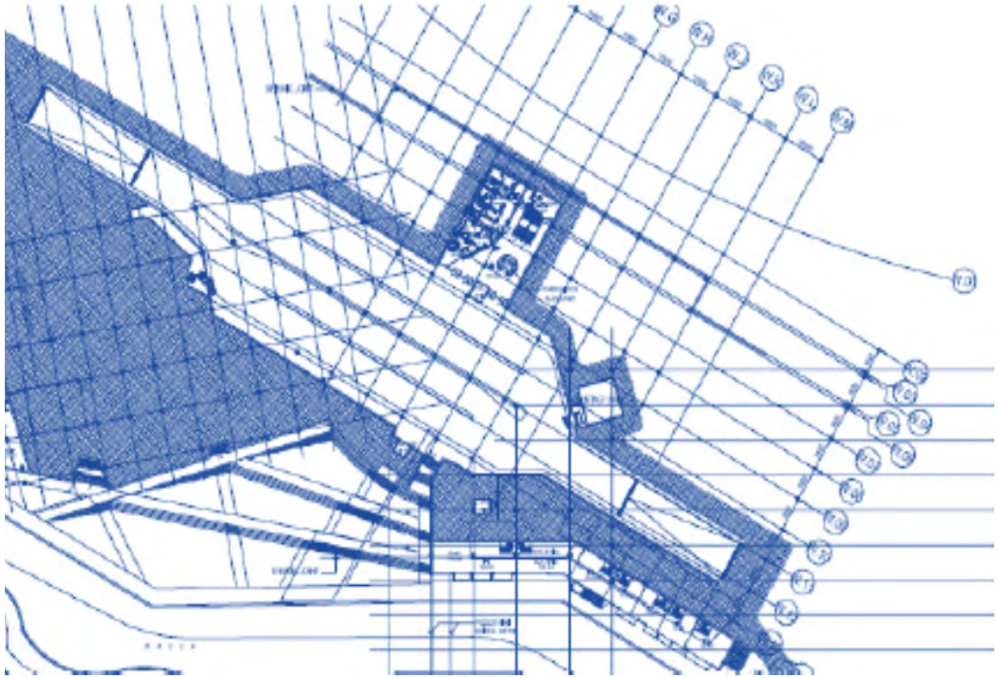


CFD ANALYSIS FOR AN UNDERGROUND SUPERMALL CARPARK TUNNEL

Solver: Fire Dynamic Simulation (FDS)

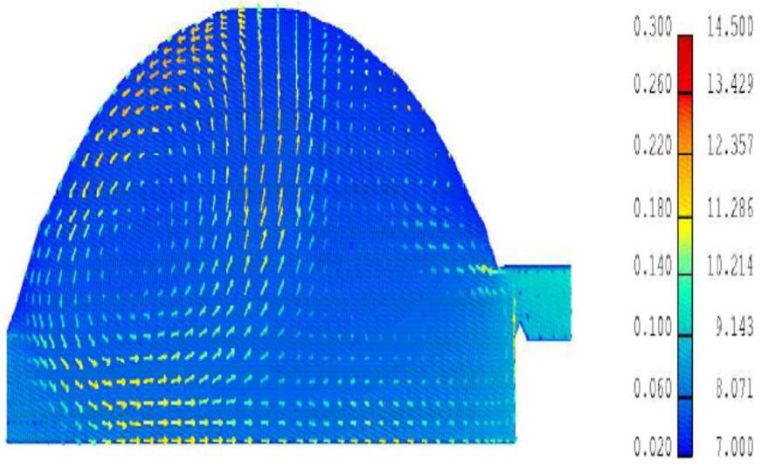
An underground road tunnel design for oxygen, car fire scenarios, carbon monoxide and carbon dioxide levels at such scenarios.

This tunnel design aims to determine the levels of dangerous pollutants that will occupy the tunnel and identify mitigating conceptual designs to counter the predicted conditions. This will also reduce the amount of time and money to be if such failure occurred in actual.



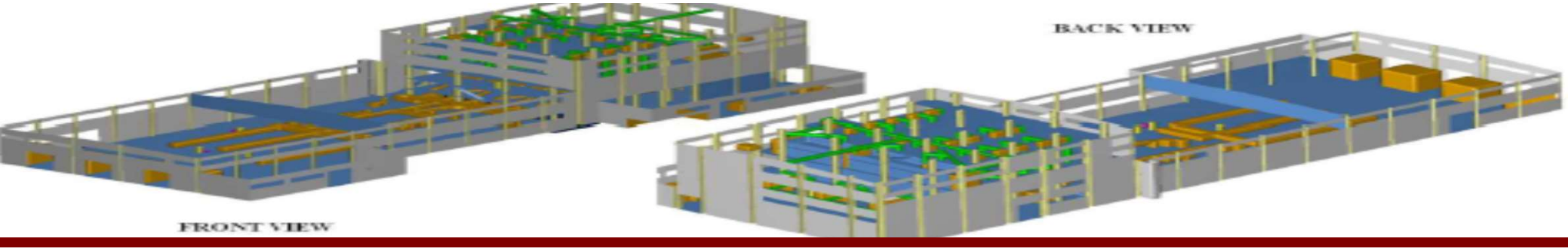
CFD ANALYSIS FOR THE METROPOLIS MALL
AIR CAVERN CATCHER FOR NATURAL VENTILATION

A 3600-TR mall natural ventilation study in the opening of the glass façade to accommodate and act as a wind catcher intake.

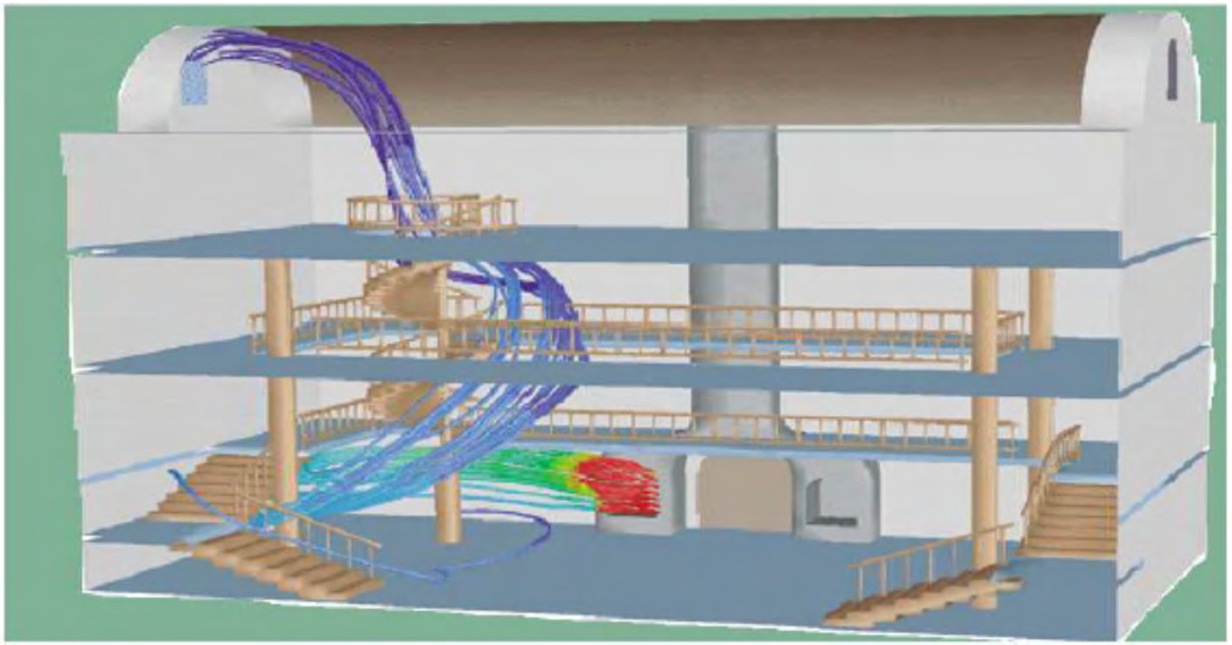


PRINCIPLES OF NATURAL VENTILATION

Different airflow principles that follows the law of natural ventilation and buoyancy were adopted in this project.



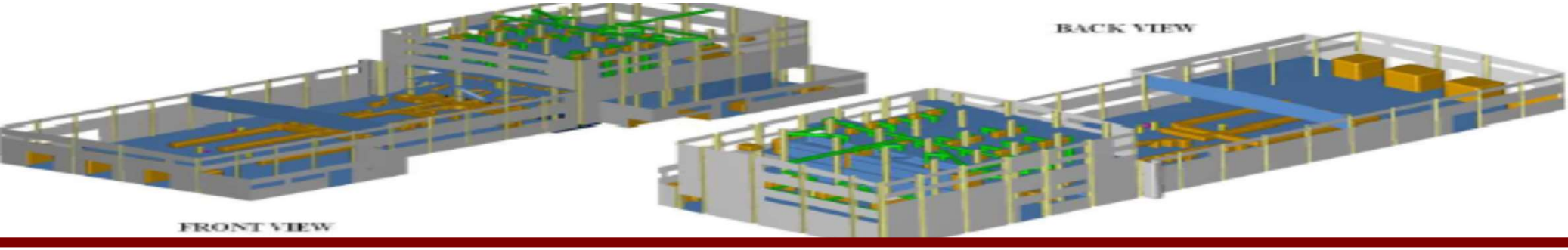
CFD ANALYSIS FOR THE METROPOLIS MALL
AIR CAVERN CATCHER FOR NATURAL VENTILATION



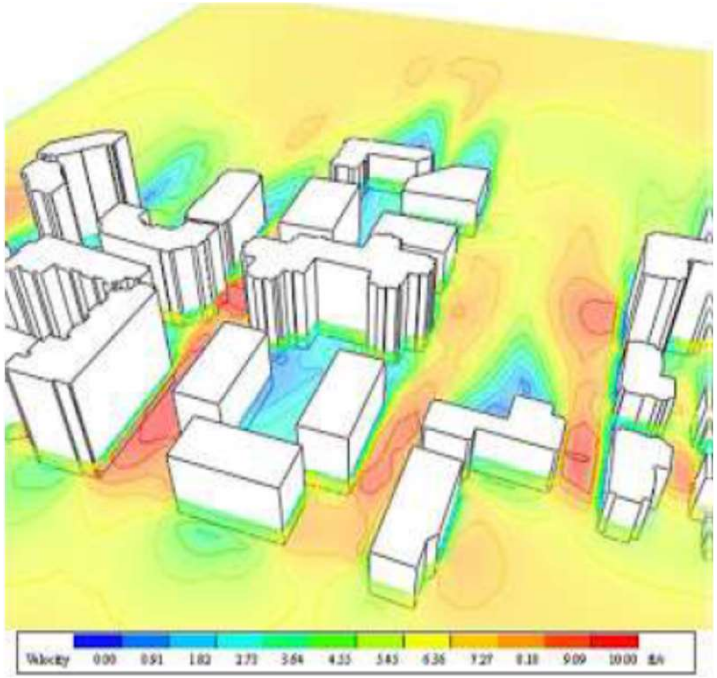
NATURAL VENTILATION – SPENT AIR

The use of the shuttered open the main hallways and corridors to serve as exit and entry of wind driven air. The use of spent cool air from the three lower floors to be released upward to assist in cooling the natural ventilation of 4th and 5th floors.

The design and provision (for occasional use during humid months) of swimming pool fountain as chilled water curtain air dehumidifier during hot and humid days to dry incoming air in the wind catcher intake. It is estimated int two to three months a year that the wind will be too hot and humid and need the cooling assistance from chilled water.

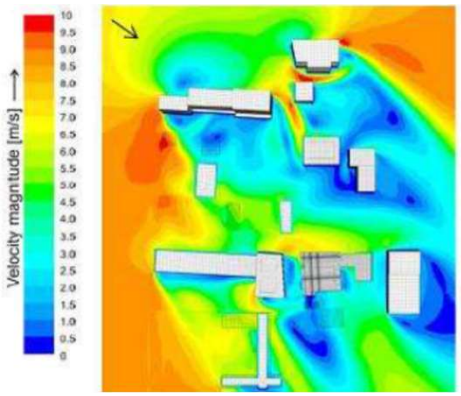


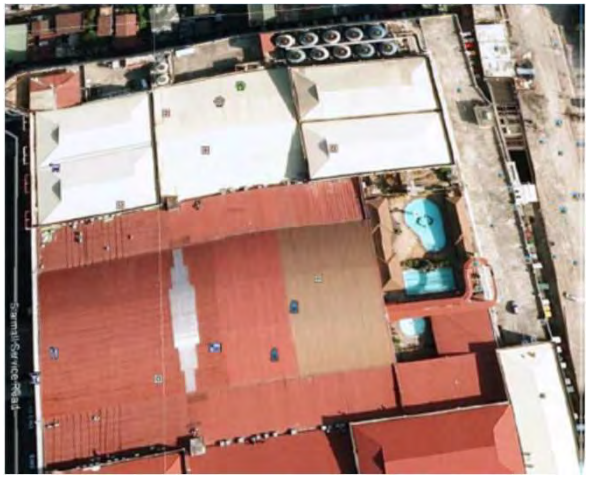
CFD ANALYSIS FOR THE METROPOLIS MALL AIR CAVERN CATCHER FOR NATURAL VENTILATION



NATURAL WIND PROFILE OVER THE AREA

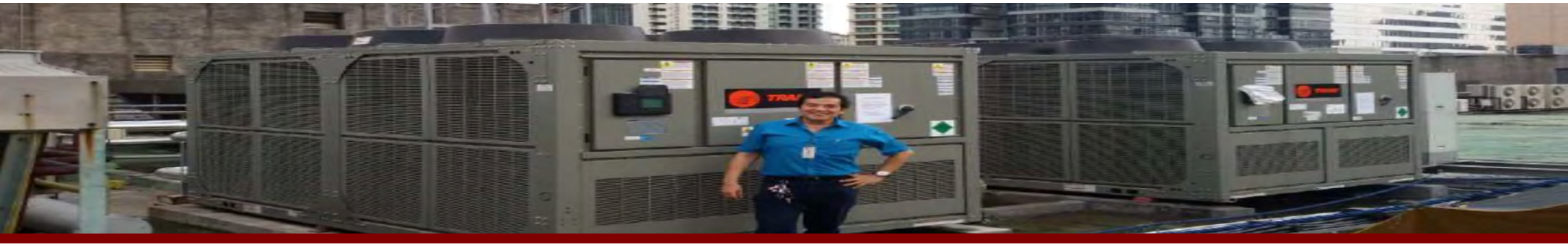
The velocity and pressure profile over the buildings surrounding the malls. Study were conducted to determine the traverse air direction influenced by barriers.





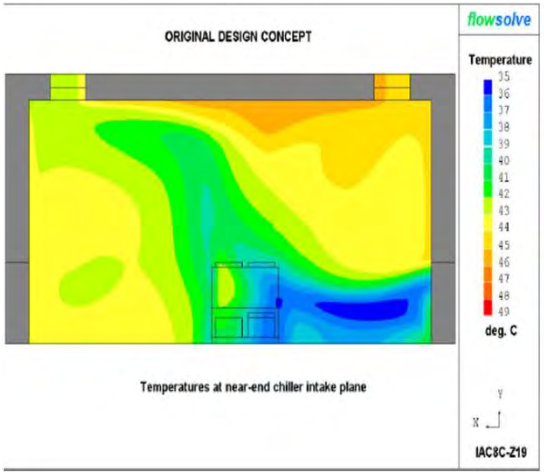
ROOF RIDGES DESIGNS

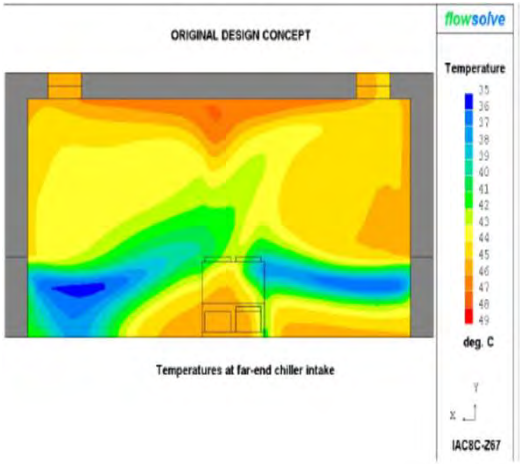
The design of the roof apex and ridges as wind-driven cross ventilation, where natural wind will be pushed and sucked out the hot air trapped in the roof level. The design acts as a cool air intake and hot air exhaust from the influence of wind driven pressures.



CFD ANALYSIS FOR AN AIR COOLED CHILLER AIR INTAKE STUDY

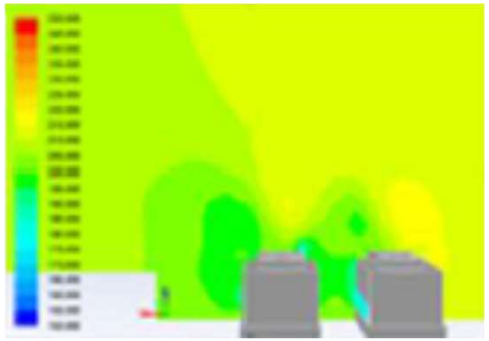
A study of air-cooled chiller configuration and the intake velocity and temperature profile in the near and far-end intake planes.

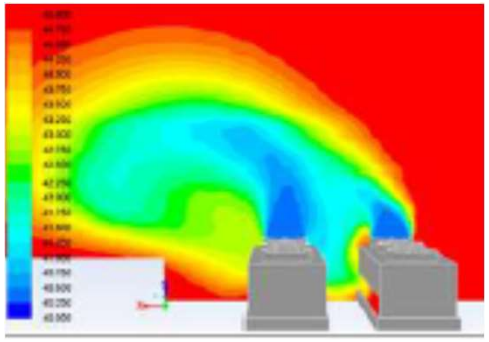




TEMPERATURE AND VELOCITY PROFILES

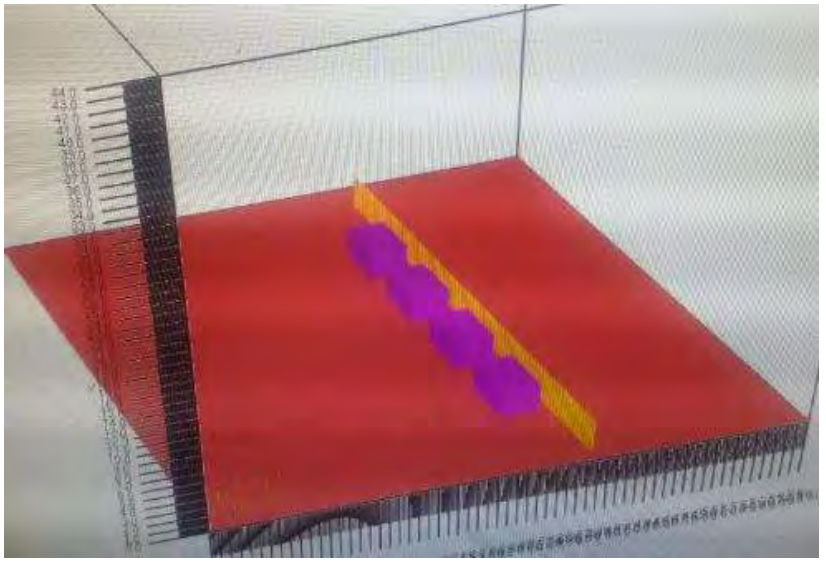
The results shows the velocity profiles (right) and temperature profiles (left) for the chiller intake and exhaust planes. The results agreed and validated the actual conditions on site.

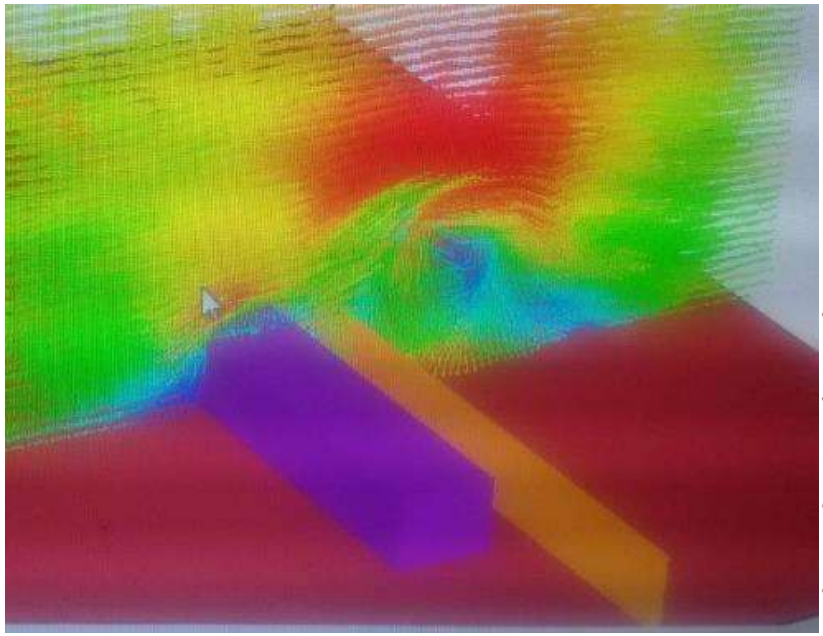


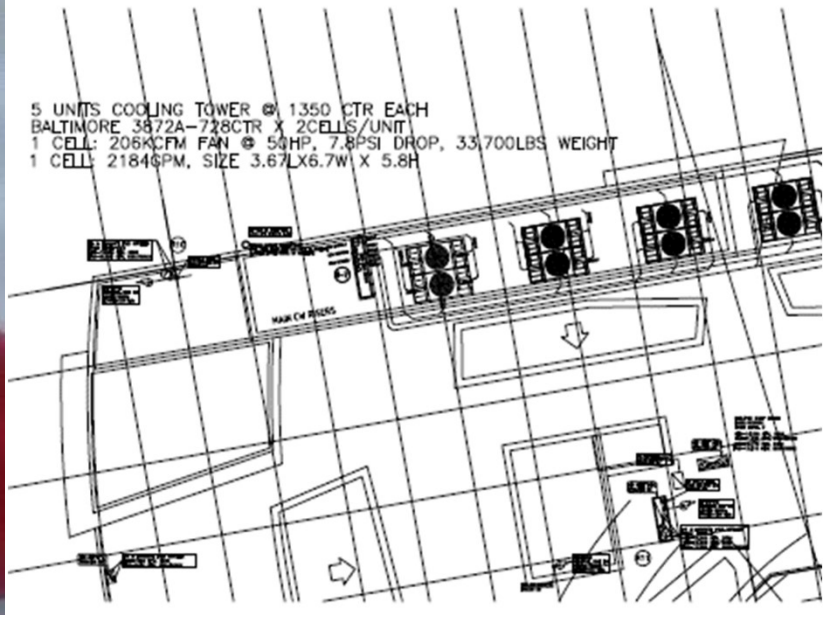


“AS DESIGNED” CFD RUN ON COOLING TOWERS

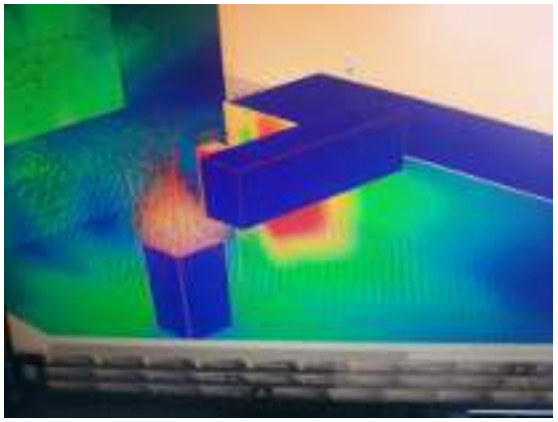
NEW FESTIVAL SUPER MALL

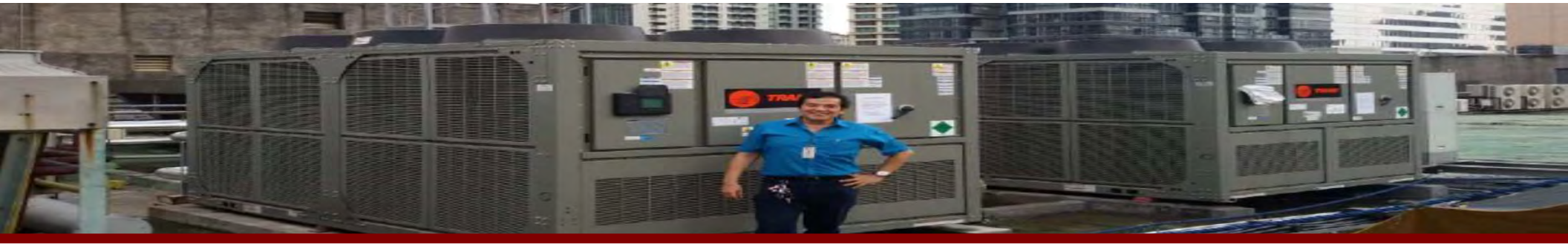






READINGS OF LOCAL VENTILATION PM2.5 PARTICLE CONCENTRATIONS





OTHER CFD PROJECTS HANDLED

- Computer Server Farms and Server Rooms
- Industrial Plant Cleanrooms
- Healthcare Facilities and Cleanrooms
- Highrise Building Wind and Stack Effects
- Carpark and Underground Tunnels ventilation
- Underground Spaces
- Naturally Ventilation of Structures
- Kitchen Comfort and Hood Exhaust Design
- Logistics and Warehouses

PERSONNEL
EQUIPMENT
SERVERS
INTRUMENTS AND TOOLS





RBSANCHEZ RESOURCES

CFD SIMULATIONS AND POST-PROCESSING

4. CFD PERSONNEL

- SITE DATA ACQUISITION AND VERIFICATION ENGINEERS
- 3D CAD ENGINEERS AND MESH ENGINEERS
- PROGRAMMERS
- POST-PROCESSING ENGINEERS
- MULTI-DISCIPLINE SCIENCES AND RESEARCH ENGINEERS (See CVs)
- OPEN SOURCE for customization of Specialists **CFD tools such as Open Foam, ANSYS, RHINO, Arduino, Grasshopper, BREAM, IESVE and LEED** design, etc. Weather and climate, Cleanroom Class 100 and design of Data Server Farms, Hydraulics behavior, Aerodynamics, Environmental Sciences, Geological Sciences, Mining, and even Non-Newtonian fluid behaviors like Bingham fluids, viscuous, forces and dynamics on pipelines and supports, etc.

ASSOCIATES, PARTNERS, ENGINEERS & STAFF

ASSOCIATE PARTNER

OSCAR RELUCIO

PME (PROFESSIONAL MECHANICAL ENGINEER)

BS IN MECH ENGG. - U.P. DILIMAN YEAR 1981

Major Experiences & Design

- Intel Technology Philippines, 2001-2007
- Amkor/Anam Phils Muntinlupa, 1991
- American Microsystems Phils. Inc., 1993
- Sunpower Phils. Inc. Fab1/Fab2 Line Expansion,
- Microsemi Semi-Conductors Manila, 2015
- 30,000sqm HSBC Data Center Project at Hongkong
- Mead Johnson (Phils) Inc., Johnson & Johnson (Phils), Inc.,
- Texas Instrument Phase 2 Bump Module Expansion, 2011
- Cypress Decatech Project Laboratory, 2010
- Procter & Gamble – Beijing
- Ford Motors Phils Inc.
- Bayer Headquarters
- Knauf Manufacturing Facility at Batangas
- Nestle Phils. Inc
- Astra Head Office and Pharmaceutical Plant Complex, 1989
- Malt Extract Plant, Lipa, Batangas
- St. Lukes's Medical Center, BGC Taguig City
- Philippine Orthopedic Center, Quezon City
- Taguig Hospital, Taguig City
- Eastern Visayas Regional Medical Center, Tacloban City
- Ospital ng Makati, Makati City
- Childrens Hospital, Pasig City
- Okada Manila, Paranaque City

Date	Position	Company
2019 – present	Associate Director	RBSanchez PME Consultants & Associates
1998 – 2019	Mechanical Director	Meinhardt Philippines, Inc.
1993 – 1998	Mechanical Head & Project Manager	PT Arnan Pratama Consultants
1989 – 1993	Mechanical Engineering Manager	RN Ferrer Associates,
1984 – 1986	Senior Mechanical Designer & Estimator	OV Roy Construction Inc.
1982 – 1983	Junior Mechanical Designer	Trans-Asia Philippines, Inc.
1981 – 1982	Junior Mechanical Estimator & Designer	Capitol Industrial Construction Group, Inc.

RBSanchez PME Consultants & Associates, Inc.

ASSOCIATE PARTNER

MARIO ALIX, PEE

Professional Electrical Engineer and Systems Specialist

CORE SKILLS

1. Detailed Design Engineering
2. Electrical System and Analysis
3. Construction ProjectManagement
4. Cleanrooms ElectricalProvisions
5. Power Distributions
6. Industrial & Commercial Designand Applications

Owner of Mario A. Alix Philippines, Inc.

- **The Outstanding Mapuan(TOM) Awardee 2008 in Professional Practice in Electrical Engineering**
- **Institute of Integrated ElectricalEngineers Awardee 2012 of The Most Outstanding Electrical Engineer**

EDUCATION

- **Bachelor of Science in Electrical Engineering** Mapua Institute of Technology,Manila

RBSanchez PME Consultants & Associates, Inc.

ASSOCIATE PARTNER

DR. ENRICO C. NERA

UP Diliman B.S. in Metallurgical Engineering

ASEAN Engg., APEC Engr., MSMEP, MAusIMM,
Masters in SME, AFEO Honorary Fellow
PRC Regulatory Board Member, Board of Metallurgical Engineering
Past President and CEO, Atlas Consolidated Mining and Development Corp

July 2021 - current	Offshore Mining Operations Manager, RBSanchez PME Consultants Inc.
September 2015 February 2020 CEO	President and CEO, Atlas Consolidated Mining and Development Corp.
September 2014 February 2018	EVP-Operations & Chief Operating Officer Carmen Copper Corporation
July 2007 – Mar 2015	President and Chief Operating Officer Minercon International
November 2002 – June 2007	Professional Regulation Commission Board Member, Professional Regulatory Board of Metallurgical Engineering
1988–1993 Philippines Sr. Metallurgist	Philex Mining Corp. Benguet,
1983–1988 Metallurgical Engineer	Marcopper Mining Corp.Marinduque, Phil.

RBSanchez PME Consultants & Associates, Inc.

ASSOCIATE ENGINEER

William Ong Jr.
(since 1979)

CFD ENGINEER/IT/MATHEMATICS

- Masters of Science in Mechanical Engineering, University of the Philippines
- Diploma in Computer Science, University of the Philippines
- Bachelor of Science in Mechanical Engineering, University of the Philippines 1978
- PRC License in Mechanical Engineering 1978

- 30 years of experience in HVAC and mechanical design

Date	Position	Company
October 2015 – present	Associate Director	RBSanchez PME Consultants & Associates, Inc
June 2009 – October 2015	Associate Director	AECOM Philippines, Inc.
November 2008 – June 2009	Senior Mechanical Engineer	GHD Philippines, Inc.
December 2002 – March 2007	Facilities Manager & Mechanical Design Lead	Intel Philippines
September 2004 – June 2006	Consultant	AMEC/Forssman Pacific Corporation
August 2001 – December 2002	Principal Mechanical Engineer	Parsons Makati
February 2001 – August 2001	Mechanical Engineer	AMEC/Forssman Pacific Corporation
April – May 1999	Consultant	Electrowatt Ekono
August 1997 – August 1998	Senior Mechanical Engineer	Bescon Consulting Engineers, Pty
December 1996 0 July 1997	Senior Mechanical Engineer	Electrowatt Ekono
April 1990 – November 1996	Chief R&D Engineer	MK Industries
June 1983 – March 1990	Various Positions	Freelance
February 1981 – June 1983	Supervising Design Engineer	DCCD Engineering Corporation
May 1978 – January 1981	Research Engineer	Bureau of Energy Development

RBSanchez PME Consultants & Associates, Inc.

ASSOCIATE DIRECTOR

ROLANDO B. SANCHEZ

STRUCTURAL CIVIL An experienced Structural Engineer with more than 32 years of experience in design and analysis of high rise buildings up to 40-storey, industrial plants,oil refinery, mining, cement plants, communication towers, guyed tower,silos, piers, revetment structures, slope protection, rockfall analysis, civil works, mining primary crusher, etc. here and abroad.

Date	Position	Company
2001 – present	Managing Principal	RBSanchez Consulting Engineers
1996 – 2000	Structural Design Manager	R.S. Caparros and Associates
1992 – 1994	Rendered Structural Design Services	International Design Group – Canada
1989 – 1992	Structural Design Head	R.S. Caparros and Associates
1990 – 1992	Rendered Structural Design Services	Various Company
1987 – 1998	Structural Design Engineer	Design Management and Development Corporation

EDUCATION

- **Advanced Structural Steel Design, Advanced Structural Analysis, Hydraulics and Hydrology, Engineering Economics**
  University of Toronto, Canada
- **Computer Aided Structural Analysis and Design**
  Seneca College, Canada
- **Bachelor of Science in Civil Engineering**
  University of Sto. Tomas

RBSanchez PME Consultants & Associates, Inc.

ASSOCIATE ENGINEER

JOSE FRANCISCO R. SANCHEZ Mining Engineer / Specialist

Apex Mining Company, Incorporated, Mining Consultant – 2021

EHMC Consulting, Inc., Principal Geotechnical Engineer – 2019

Besra Gold Inc., Vietnam, Consultant and Project Manager – 2016

Besra Gold Inc., Malaysia, Senior Geotechnical Engineer – 2012 to 2014

Golder Associates, Australia, Senior Geotechnical Engineer – 2012

Olympus Pacific Minerals Inc., Malaysia, Environment Manager – 2010-2012

Kinbauri Gold Espana S.L., Spain, Chief Mining Engineer – 2008-2009

RRMI Lafayette Mining Ltd, Rapu-Rapu Mine, Mine Geotechnical Engineer – 2005

Lepanto Consolidated Mining Co., Senior Mining, Geotechnical Engineer – 1999–2005.

Philex Mining Corporation and Philex Gold Philippines Inc., Sibutad Project, Mining Engineer – 1996-1999

EDUCATION

- **Board Topnotcher, 1st PLACER** in the 1996 Mining Engineering Licensure Examination
- **M.S. Civil Engineering, major in Geotechnical Engineering**, Mapua Institute of Technology. 2014-2015
- **B.S. Mining Engineering**. Mapua Institute of Technology. 1996.

ASSOCIATE ENGINEER

RAFAEL M. SANCHEZ BSCE Masters in Science

Structural Engineering, Civil Engg. and CPEng Onshore/Offshore

MSc Oil and Gas Structural Engineering, University of Aberdeen, Scotland, 2013

B.S., Civil Engineering, University of the Philippines, 2003

SPECIAL AWARDS

14th Place	**Out of over 6000 examiners in the National CE board exam**	**November 2003**
Top Performer of the Month	MPP Project – Worleyparsons	February 2016
With commendation award	MSc in oil and gas structural Engineering	September 2013
Spotlight Award	DOW/PIC Olefins II Kuwait Project - Fluor	November 2006

2017 – 2020	Director / Senior Engineer – RMS Offshore Engineering Pty Ltd, Melbourne, Australia
2014 - 2017	Principal Civil and Structural Engineer - WorleyParsons, Al Khobar, Saudi Arabia
2008 - 2014	Civil and Structural Engineer – Woodgroup PSN, Melbourne, Australia
2005 - 2008	Civil and Structural Engineer – Fluor Corporation, Alabang, Philippines

RBSanchez PME Consultants & Associates, Inc.

ENGINEERS & STAFF

DIRECTOR of ENGINEERING

Nick Johnsonn B. Fernandez, BSME

President Ramon Magsaysay State University

PRC Mechanical Board Exams 2018
Possible "12th PLACE", Board Licensure Score of 92%.

A WELL-ROUNDED Engineer who combines both theory and practical experience.

Excellent in complex math, programming in using **CFD tools such as Open Foam, RHINO, Arduino, Grasshopper, BREAM, IESVE and LEED** design, etc. down to ISO Cleanroom Class 100 and design of Server Farms, and final multi-discipline projects complete with testing and CX works, turover, maintenance and operations.

Expert in the use of test equipment and measurements to confirm CFD models for thermodynamics, hydrodynamics, environmental and CFD projects in IT SERVER airflows, heat island effects in cleanrooms in semiconductors, water treatment and chemical and sludge and viscuous slurries and mine processing plants.

RBSanchez PME Consultants & Associates, Inc.

ENGINEERING ASSOCIATE

JOEY MICHAEL PEÑA PORTE

PME (PROFESSIONAL MECHANICAL ENGINEER)

PRC Mechanical Board Exams 1996

Sixth (6th Placer) in the PRC Mechanical Engineer Board Licensure Examination

- **University of Nueva Caceres** 1990-1995 Naga City, Philippines

WORK EXPERIENCE:

Mechanical Engineer - (HVAC, Plumbing , Drainage & Fire Fighting)
Construction Development Company (CDC) / (2008 – 2017)
Doha, Qatar
2013 Ministry of Municipality in Urban Planning & Development Authority
Certified Mechanical Engineer – MM UPDA (Qatar)- Grade “A”
2021 U.S. Army Corps of Engineers (USACE)
Al Udied US Air Base – Qatar
Corps of Engineers and Naval Facility Engineering Command Training Course
Construction Quality Management (CQM) - Certified Mechanical Engineer

SENIOR MECHANICAL ENGINEER

Dennis B. Sarita

Bachelor of Science in Mechanical Engineerin
University of Eastern Philippines

Snamprogetti /Saipem Saudi Arabia Ltd SAUDI ARAMCO

WASET HOOK UP PROJECT (ARABIYAH / HASBAH OFFSHORE FACILITIES), Saudi Arabia

Khurais Central Processing Facility xpansion & Satellite, Saudi Arabia
March 01, 2017 to June 27 ,2020

Complete Shedgum-Yambu Pipeline Project, Saudi Arabia
February 19, 2015 to July, 2020

RBSanchez PME Consultants & Associates, Inc.

SENIOR MECHANICAL ENGINEER

Peter R. Vasquez, ME, MSME

Bachelor of Science in Mechanical Engineering, University of the East – Manila (2013)
"MAGNA CUM LAUDE"
"COLLEGE DISTINGUISHED GRADUATE AWARDEE"

Master of Science in Mechanical Engineering, University of the Philippines – Diliman (2018)

PRC Mechanical Board Exams 2013
Licensed Mechanical Engineer

Projects Handled:

Client:	Araneta Center, Inc.
Project:	**Professional Design & Consultancy Services for the Air-Conditioning and Ventilation System for Cyberpark Tower 3**
Position:	Lead Engineer
Date:	March 2019-Present
Client:	Maynilad Water Services, Inc.
Project:	**Consultancy Services for the Evaluation of 12 Pump Stations, RBSanchez is the GHD Nominee for the Project**
Position:	Lead Engineer
Date:	November 2018-Present
Client:	ZAMA Precision Industry Manufacturing Philippines
Project:	**HVAC System Design and Consultancy for ZAMA Die Casting Plant using Computerized Fluid Dynamics, RBSanchez as design consultant together with TCGI Engineers**
Position:	Lead Engineer
Date:	August 2018-October 2018
Client:	Math Breeder Farm, Inc.
Project:	**Clean Room-Biological Area, Chicken and Egg Farm HVAC System Design**
Position:	Assistant Engineer
Date:	March 2018-Present

RBSanchez PME Consultants & Associates, Inc.

MECHANICAL ENGINEER

DREXLER G. DELA TORRE, ME

Bachelor of Science in Mechanical Engineering, BSME
St. Louis University, Baguio (2018)
Graduated "CUM LAUDE"

"3rd PLACER" - PRC Mechanical Board Exams 2018

RBSanchez PME Consultants & Associates, Inc.

MECHANICAL ENGINEER

ROBERTO F. MENDOZA JR., M.E.

DON MARIANO MARCOS MEMORIAL STATE UNIVERSITY – MLUC

San Fernando City, La Union Bachelor of Science in Mechanical Engineering 1983 - 1988

Mechanical Package Superintendent
PT Saipem Indonesia
LNG Tangguh Expansion -Train 3
March 14, 2021 – January 13, 2022

MECHANICAL ENGINEER

KYLE ADRIAN APONESTO, ME

Mapua University
Bachelor of Science in Mechanical Engineering
(2018-2022)

Board exam rating: 89.3

Skills: Autocad, Autodesk Fusion 360, Matlab

RBSanchez PME Consultants & Associates, Inc.

ADMIN MANAGER

ROSE R. SABIO

BACHELOR OF SCIENCE IN INFORMATION TECHNOLOGY
PHILIPPINE COLLEGE OF TECHNOLOGY(DAVAO CITY, 2012-2015)

COMPUTER HARDWARE SERVICING NC11
ASIAN BUSINESS INSTITUTE OF E-TECHNOLOGY (BACOLOD CITY, 2008-2009)

VIRTUAL ASSISTANT FOR 5 YEARS
*MANAGER OF EBAY STORES IN AUSTRALIA, U.S.A AND U.K ACCOUNTS (RESPONSIBLE TO TRAIN OTHER VA, SET-UP BUSINESS POLICIES, SEARCH PROFITABLE PRODUCTS, CUSTOMER SERVICES, HANDLE PAYPAL DISPUTES, AND DAILY SALES OF THE ACCOUNTS)

MCR Bles Foods Trading Co.
*ENCODER FOR 6 MONTHS

PHILIPPINE STATISTICS AUTHORITY
*OJT ENCODER FOR 3 MONTHS

RBSanchez PME Consultants & Associates, Inc.

ADMIN EXECUTIVE

Charo T. Tamayo

Administration Business Management (ABM)
AMA Education System
ABE International Business College Makati(2016-2019)

TECHNICAL ASSISTANT

Cipriano T. Tamayo Jr.

Mechanical Field Technician
Electrical-Acres Professional Institute Dagupan city (2009)

Experienced in Data gathering, logging and Instruments, IT, Electrical and Mechanical Field Technical Assistant

RBSANCHEZ PME CONSULTANTS & ASSOCIATES INC.,
PERSONNEL ORGANIZATIONAL CHART

RBSanchez PME Consultants & Associates, Inc.

RESOURCE/OFFICES:

With complete Personnel Support and resources for:

1. AutoCad Drafting and Large format Plotting
2. Complete Engineering softwares (with license): Elite Duct Size 3.0, PsychartHD 7.4, Flite FluidFlow Pipe and Duct Ver 3.0., ASHREA Fundamentals 2013, Trace 700 Cooling Load, CHVAC Heat Load, PipeSizer, Autocad Suite 2013, Cloud computing, and a lot more.
3. Dedicated FTP site for large file transfer

RBSanchez PME Consultants & Associates, Inc.

RBSanchez PME Consultants & Associates, Inc.

RBSanchez PME Consultants & Associates, Inc.

LOCAL EQUIPMENT FOR CALCULATION AND POST-PROCESSING

THREE PARALLEL COMPUTING
BLADE SERVER UNITS
HP PROLIANT DL380 G3 SERVERS

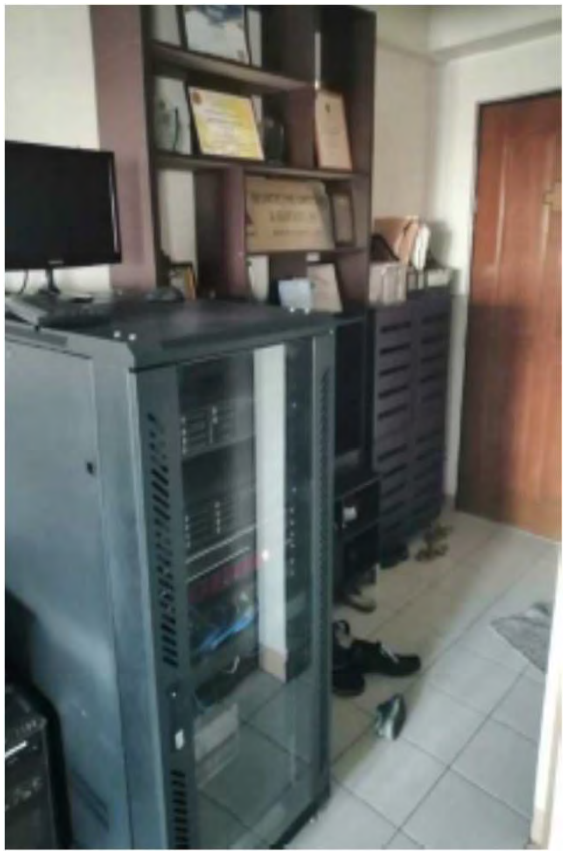
INTEL XEON DOUBLE PROCESSOR
32 CORES 3.0 MHZ BASE

128 GB RAM 3600 MHZ

DEDICATED FTP SERVERS

LOCAL SSD STORAGE

SYNOLOGY CLOUD STORAGE



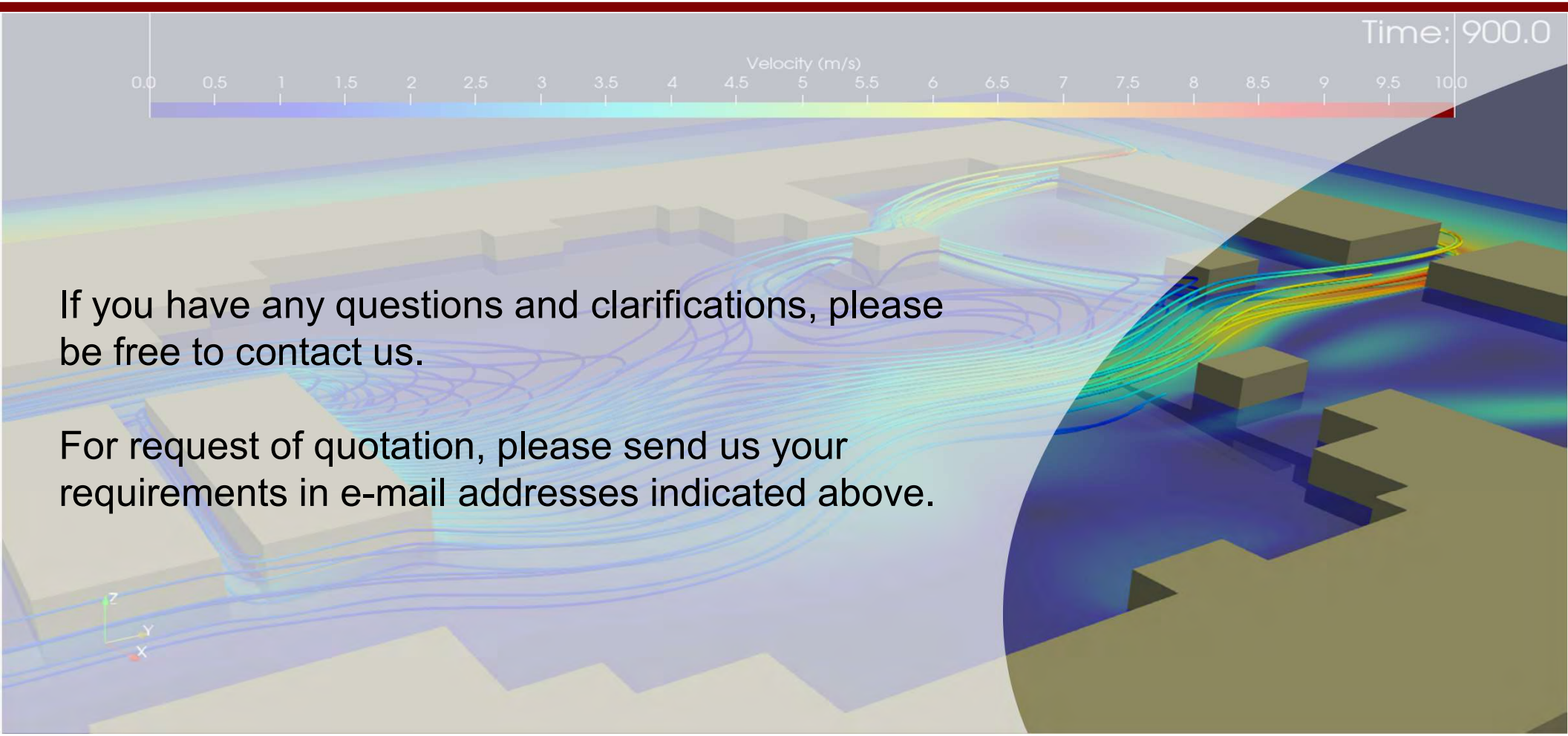
RBS PRECISION INTRUMENTS FOR CASE VALIDATIONS

LIST OF MAJOR INSTRUMENTS

Ultrasonic Flowmeters
Ultrasonic Thickness Gauging
Anemometers
Pressure Gauges
Particle Counters
CO Data Loggers
Tachometers
Temperature And RH Meters
Thermography Cameras
Voltmeters
Ammeters
Oxygen Level Meters
Bimetal Thermometers
Laser Meters
Thermal Scanners

RBSANCHEZ PME CONSULTANTS & ASSOCIATES, INC.
www.rbs-engineers.com

U3603 36F, Makati Executive Tower II, Dela Rosa St., Makati City, Philippines 1230
info@rbs-engineers.com
rosensanchez@yahoo.com
(02) 8776 – 5879 / 8638-2604
(+63) 927-300-6000 / 947-507-0000



If you have any questions and clarifications, please be free to contact us.

For request of quotation, please send us your requirements in e-mail addresses indicated above.

CONTACT US!

RBSanchez PME Consultants & Associates, Inc.

Unit 3603, 36F Makati Executive Tower II, Buendia Ave. cor. Dela Rosa St.
Brgy. Pio Del Pilar, Makati City Philippines 1230

(+632) 8776-5879, 8638-2604,
8809-8106;

(+63) 927-300-6000 / 947-507-000

info@rbs-engineers.com
rosensanchez@yahoo.com

www.rbs-engineers.com

Thank you!

RBSanchez PME Consultants & Associates, Inc.

Unit 3603, 36F Makati Executive Tower II, Buendia Ave. cor. Dela Rosa St.
Brgy. Pio Del Pilar, Makati City Philippines 1230

(02) 8776 – 5879

(+63) 927-300-6000 / 947-507-000

info@rbs-engineers.com
rosensanchez@yahoo.com

www.rbs-engineers.com